HUMAN

PHYSIOLOGY.

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HUMAN

PHYSIOLOGY.

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ETC. ETC. ETC.

WITH WHICH IS INCORPORATED,

MUCH OF THE ELEMENTARY PART OF THE

INSTITUTIONES PHYSIOLOGICÆ

OF

J. F. BLUMENBACH, M.D. F.R.S.

PROFESSOR IN THE UNIVERSITY OF GÖTTINGEN.

ILLUSTRATED WITH NUMEROUS WOOD-CUTS.

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TO

THE STUDENTS

OF THE

UNIVERSITY OF LONDON,

THIS WORK

IS

AFFECTIONATELY INSCRIBED.

PREFACE.

In 1815, I translated the third edition of Professor Blumenbach's "Institutiones Physiologicæ," anonymously, with the addition of twenty pages of notes; the whole amounting to two hundred and sixty pages.

In 1817, I published a second edition, with my name, and the addition of a hundred and fifty pages of notes; the whole amounting to four hundred and twenty-six pages.

In 1820, I published a third edition, with two hundred pages of notes, in smaller type than the text; so that, although the whole amounted to four hundred and sixty-five pages, the matter of my notes very nearly equalled that of the text.

In 1824, I published a fourth edition, from a new edition which had appeared of the original work in 1821. The notes, still in smaller type, filled three hundred and fifty pages, and the whole amounted to five hundred and eighty-one; so that the matter of my notes greatly exceeded that of the text.

Finding that, in the present edition (which, through my engagements, has been delayed long after the preceding was out of print), my own matter would very much exceed that

of Blumenbach, and that much of the original would require emendation on account of recent discoveries or might be better omitted, and that the disjointed nature of the work would be a source of greater inconvenience to the reader than ever, I resolved to remodel the whole, omitting many parts of the original, and blending my notes with as much of it as I could retain: and as the portions of the original retained are of so much smaller amount than my own labours, and of a very elementary character, and the proportions of Blumenbach's share and my own thus completely reversed, I feel satisfied that, in now giving my own name to the work, I shall be justified in the eyes of even the celebrated and venerable Blumenbach, who, though eighty-three years of age, still delivers his lectures at eight o'clock every morning. The passages with inverted commas and no farther intimation are from Blumenbach. I have illustrated many pages with woodcuts, from Dr. Jules Cloquet's collection, for the sake of the general reader; since works of this description are now read as much out of the profession as by medical men.

The correction of any errors, and the communication of any facts, either publicly or privately, will always be esteemed by me a valuable favour.

37. Conduit Street,
Feb. 14. 1835.

HUMAN PHYSIOLOGY.

I. GENERAL PHYSIOLOGY.

CHAPTER I.

GENERAL VIEW OF THE OBJECTS OF NATURE, AND OF MAN AS DISTINGUISHED FROM THE REST.

NUMEROUS authors have remarked that a gradation exists among all the objects of the universe, from the Almighty Creator, through archangels and angels, men, brutes, vegetables, and inanimate matter, down to nothing.

> "Vast chain of being which from God began,
> Natures ethereal, human, angel, man,
> Beast, bird, fish, insect, what no eye can see,
> No glass can reach, from infinite to thee,
> From thee to nothing." [a]

Yet this gradation, striking as it is, deserves not the epithet regular or insensible. "The highest being not infinite must be, as has been often observed, at an infinite distance below infinity." "And in this distance between finite and infinite there will be room for ever for an infinite series of indefinable existence. Between the lowest positive existence and nothing, wherever we suppose existence to cease, is another chasm infinitely deep; where there is room again for endless orders of subordinate beings, continued for ever and ever, and yet infinitely superior to

[a] Pope, *Essay on Man*, Epistle 1.

non-existence." "Nor is this all. In the scale, wherever it begins or ends, are infinite vacuities. At whatever distance we suppose the next order of beings to be above man, there is room for an intermediate order of beings between them, and if for one order then for infinite orders; since every thing that admits of more or less, and, consequently, all the parts of that which admits them, may be infinitely divided. So that, as far as we can judge, there may be room in the vacuity between any two steps of the scale, or between any two points of the cone, for infinite exertion of infinite power." [b]

In fact, at how vast a distance do we see the innate mental properties of man standing above those of the most sagacious brute! How immensely does the volition of the lowest animal raise it above the whole vegetable kingdom! And how deep the chasm between the vital organisation of the meanest vegetable and a mass of inanimate matter! Gradation must be admitted, but it is far from regular or insensible. Neither does it at all regard perfection of system, nor very much the degree, but chiefly the excellence, and, within the limits of the visible world, the combination, of properties. Man, placed at the summit of terrestrial objects by the excellence of his mind and the combination of the common properties of matter, of those of vegetables, and of those of brutes, with those peculiar to himself, is surpassed by the dog in acuteness of smell and by the oak in magnitude, nor can he boast of more perfection than the gnat or the thistle in their kinds.

Substances consist of Particles endowed with certain properties without which their existence cannot be conceived, *viz.* extension and impenetrability; with others which proceed, indeed, from their existence, but are capable of being subdued by opposing energies, *viz.* mobility, inertness; and with others apparently neither necessary to their existence nor flowing from it, but merely superadded: for example, various attractions and repulsions, and various powers of affecting animated systems.

INANIMATE SUBSTANCES may be gaseous, liquid, or solid. If solid, the inanimate body has no properties which are not analogous to these, or even dependent upon them. It is for the most part

[b] Dr. Johnson, *Review of a Free Enquiry into the Nature and Origin of Evil.*

homogeneous in its composition, and disposed to be flat and angular, increases by external accretion, has an indeterminate volume, and contains within itself no causes of decay. The rest of the bodies in nature are *animated*, and are vegetables and animals.

VEGETABLES, in addition to the properties of inanimate matter, possess those of LIFE, *viz.* sensibility (without consciousness or perception)—I would say excitability, for sensibility without the power of sensation is nonsense,—and contractility; or I would rather express both by the term excitability.[c] Their structure is beautifully organised, their volume is determinate, and their surfaces disposed to be curved; they grow by interstitial deposition, changing substances to their own nature, and are destined in their very nature for a limited existence,—a period of increase and decay. They contain fluids, some of which they receive, others they produce, and others they discharge.

ANIMALS, in addition to the properties and characteristics of vegetables, enjoy MIND, the indispensable attributes of which are the powers of consciousness and perception, and of volition: the two former,—which are in truth but one, termed consciousness when it takes cognisance of internal impressions, and perception when of external,—without the latter, would be, like vegetable or organic sensibility without contractility, were this possible, useless; and the latter could not exist without the former[d], any more than vegetable or organic contraction could occur without excitability: nor can the existence of mind be conceived without the faculties of consciousness, perception, and volition, any more than the existence of matter without extension and impenetrability. The possession of mind by animals necessarily implies the presence of a brain for its exertion, and of a nerve or nerves for the purpose of conveying impressions to this brain, and at least volitions from it to one or more voluntary muscles. A system

[c] By their possession of the former, stimuli act upon them, and by the latter, they upon stimuli: by the sensibility and contractility of the vessels, substances are taken in by the roots, circulated through the system, and converted into the various parts of the vegetable. Yet this does not imply perception, consciousness, or will. The excitability of the absorbents and secretories of our own system carries on absorption and secretion without our consciousness or volition.

[d] "*Sense*," says Hamlet to his mother, "sure you have,
Else could you not have *motion*." Act iii. Sc. 4.

which is not thus gifted certainly deserves not the name of animal.[e]

Notwithstanding the vast interval which of necessity exists between the animal and vegetable kingdoms, the lowest brutes approach as nearly as possible in organisation, and consequently in function, to vegetable simplicity. They possess merely consciousness and perception, and volition, with the appetite for food, or are even nourished by imbibition, and multiply by shoots, fixed like vegetables to the spot which they inhabit. The five senses, sexual appetite, instincts, memory, judgment[f], and loco-

[e] I cannot conceive an animal without consciousness, perception, and volition; nor can I conceive these in an animal without a brain, any more than the secretion of bile without a liver, or something analogous. I contend not for the name, but for the thing. Zoologists indeed affirm that many internal worms and all the class of zoophytes have no nervous system. But comparative anatomy is yet imperfect, the examination of minute parts is extremely difficult, and new organs are daily discovered. Blumenbach, after remarking that, except those animals which inhabit corals and the proper zoophytes, most genera of the other orders of the Linnæan class of vermes are found to possess a distinct nervous system, adds: "although former anatomists have expressly declared in several instances that no such parts existed." (*Comparative Anatomy*, ch. cxvi. F.) Besides, some beings have been denominated animals without any very satisfactory reason.

Where the nervous system of an animal cannot be readily detected, its presence may be inferred from motions evidently voluntary, such as retraction upon the approach of footsteps, — proving the existence of an organ of hearing, a brain, and nerves: motion in a part *directly* stimulated, as the contraction of an hydatid upon being punctured, is no proof of an animal nature, for this is common to vegetables, for instance, the leaves of the *dionæa muscipula*, which contract forcibly on a slight irritation. It may likewise be inferred from the presence of a stomach, because, where there is a stomach, the food is taken in, not by absorbing vessels constantly plunged in it, but by a more or less complicated and generally solitary opening regulated by volition. John Hunter contended that the stomach was the grand characteristic of the animal kingdom.

[f] I see daily instances of something deserving some such name as judgment or reason in brutes. To the incredulous I offer the following anecdote in the words of Dr. Darwin. "A wasp on a gravel walk had caught a fly nearly as large as itself. Kneeling on the ground, I observed him separate the tail and the head from the body part to which the wings were attached. He then took the body part in his paws and rose about two feet from the ground with it; but a gentle breeze wafting the wings of the fly turned him round in the air and he settled again with his prey upon the gravel. I then distinctly observed him cut off with his mouth first one of the wings and then the other, after which he flew away with it unmolested with the wind." *Zoonomia:* Instinct. — The works of the two Hubers, *Sur les Abeilles* and *Sur les Mœurs des Fourmis indigènes,* furnish

motive power, with the necessary organs, are variously superadded, and endless varieties of organisation constructed, so that air and water, the surface and the crust of the earth, are all replenished with animals completely calculated for their respective habitations.[g]

Man, besides the common properties of animals, has others which raise him to an immense superiority. His mind is endowed with powers of the highest order that brutes have not, and his body being, like the bodies of all animals, constituted in harmony

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an abundance of most interesting instances of reason in those insects. See also Mr. Smellie's paper in the *Transact. of Royal Society of Edinburgh*, vol. i. p. 39. sqq.

[g] An error has been committed not only in representing the gradation regular, but in supposing every species of animal to constitute a distinct step in the gradation. "The whole chasm in nature," says Addison (*Spectator*, No. 519.), "from a plant to a man, is filled up with divers kinds of creatures, rising one above another, by such a gentle and easy ascent, that the little transitions and deviations from one species to another are almost insensible." "All quite down from us," says Locke (*Essay on the Human Understanding*, b. iii. c. 6.), "the descent is by easy steps, and a continued series of things, that in each remove differ very little one from the other. There are fishes that have wings, and are not strangers to the airy region; and there are some birds, that are inhabitants of the water; whose blood is cold as fishes, and their flesh so like in taste that the scrupulous are allowed them on fish days. There are animals so near of kin both to birds and beasts, that they are in the middle between both: amphibious animals link the terrestrial and aquatic together, seals live at land and at sea, and porpoises have the warm blood and entrails of a hog; not to mention what is confidently reported of mermaids or sea men." "In respect of our intellectual and moral principles," remarks Mr. Dugald Stewart (*Outlines of Moral Philosophy*, par. 109.), "our nature does not admit of comparison with that of any other inhabitant of this globe: the difference between our constitution and theirs being a difference, not in degree, but in kind. Perhaps this is the single instance in which that regular gradation, which we, every where else, observe in the universe, fails entirely."

Now the various kinds of animals do certainly run into each other; — there are no great peculiarities of construction in single organs between which and the ordinary structure of the same organs in other animals an intermediate structure connecting the two are not continually brought to light by naturalists. No two are so different but that discoveries are continually made of a third intermediate. *But connection is not gradation.* Many kinds, and the intermediate ones by which they are united, are all on a level in point of excellence and combination of properties, so that a single step in the gradation may comprehend a great number of kinds: — the whole vegetable kingdom forms but one step.

with the mind that the powers of the latter may have effect, differs necessarily in many points of construction from the body of every brute. Well might Shakspeare exclaim, "What a piece of work is man! How noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals!"[h]

The orang utans approach the nearest of all brutes to the human subject. Possessing expression of countenance, elevation of forehead, and less projection of the lower part of the face than other brutes, anterior extremities that are really arms and hands, and teeth of the same number and pretty much of the same figure as our own; curious, imitative, covetous, social; said by some to place sentinels and dispose themselves in a train for the propagation of alarm; to seem now and then to laugh and weep[i], to walk a little occasionally erect, to defend themselves with sticks and stones, to copulate face to face, to carry their young either in their arms or on their backs, and to be very lascivious in regard to our species; — the orang utans at first sight afford, if any of the genus can afford, a little probability to the opinion of a close connection between apes and the human race. Uncivilised men, too, make a slight approach in many corporeal particulars, as we shall hereafter find, to the structure of other animals, and since, also, the circumstances of their existence call into action few of the peculiar mental powers of our nature, they have been adduced in corroboration of this opinion. But *the least examination* displays differences of the greatest magnitude between the human and the brute creation.[k] These we shall review under two divisions, the

[h] *Hamlet,* Act ii. Sc. 2.

[i] Le Cat (*Traité de l'Existence du Fluide des Nerfs,* p. 35.) asserts that he had seen the jocko or chimpanzee (*simia troglodytes*) both laugh and cry. The reader will remember the lines in Milton's Paradise Lost (B. ix.), —

> "Smiles from reason flow,
> To brute denied."

The orang utans exhibited a few years ago at Exeter 'Change, — the one a satyrus and the other a chimpanzee, — are said by their keepers to have sometimes laughed when much pleased, but never to have wept. Steller states the fact of weeping in regard to the phoca ursina; Pallas, in regard to the camel; and Humboldt, in regard to a small American monkey. Mr. Lawrence, *Lectures,* p. 236.

[k] In La Fontaine's charming fable of *Le Singe et le Dauphin,* the former

first embracing the mental, and the second the corporeal, characteristics of mankind.

In judging of the *mental* faculties of mankind[1], not merely those should be considered which an unfortunately situated individual may display, but those which all the race would display under favourable circumstances. A seed and a pebble may not on a shelf appear very dissimilar, but, if both are placed in the earth, the innate characteristic energies of the seed soon become conspicuous. A savage may in the same manner seem little superior to an orang utan, but, if instruction is afforded to both, the former will gradually develope the powers of our nature in their noble superiority, while the latter will still remain an orang utan. The excellence of man's mind demonstrates itself chiefly

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during a shipwreck, near Athens, resolves to profit by his resemblance to man, for whom the dolphin was anciently said to have a great regard. (See Pliny, *Hist. Nat.* ix. 8, 9.) In the hurry,

Un dauphin le prit pour un homme,
Et sur son dos le fit asseoir
Si gravement, qu'on eut cru voir
Le chanteur que tant on renomme.

Just before landing him, the dolphin asked whether he often saw the Piræus, to which he unfortunately replied,

Tous les jours : il est mon ami :
C'est une vieille connaissance.

One glance was sufficient to discover the difference between a man and a monkey.

Le dauphin rit, tourne la tête ;
Et, le magot considéré,
Il s'apperçoit qu'il n'a tiré
Du fond des eaux rien qu'une bête ;
Il l'y replonge, et va trouver
Quelque homme à fin de le sauver.

" The difference between the volume of the brain of the orang utan and man is as 5 to 1 : their convolutions differ considerably in number and structure ; the anterior lobes especially are narrowed into a cone, flattened above, hollowed out below, &c. and the difference is much more striking in other apes." Gall, l. c. t. vi. p. 298.

[1] In the external senses of at least smelling, hearing, and seeing, man is surpassed by brutes. Whether they have any sense not possessed by us I cannot pretend to say.

by his voice and hands. Witness the infinite variety and the depth of thought expressed by means of words: witness his great reasoning powers, his ingenuity, his taste, his upright, religious, and benevolent, feelings, in his manufactories, his galleries of the fine arts, his halls of justice, his temples, and his charitable establishments. Besides the qualities common to all animals, each of which he, like every animal, possesses in a degree peculiar to himself, and some indeed in a degree very far surpassing that in which any brute possesses them, for instance, benevolence, mechanical contrivance, the sense for music and language, and the general power of observation and inference respecting present circumstances, he appears exclusively gifted with at least feelings of religion and justice, with taste, with wit, and with decided *reflecting* faculties of comparing and reasoning into causes.

The *corporeal* characteristics of mankind are not less striking and noble.[m] Among the beings beheld by Satan in Milton's Paradise,

> "Two of far nobler shape, erect and tall,
> Godlike erect, with native honour clad,
> In naked majesty seem'd lords of all." [n]

The erect posture is natural and peculiar to man.[o] All nations walk erect, and, among those individuals who have been disco-

[m] Consult Blumenbach, *De Generis Humani Varietate Nativa.* Sect. i. De Hominis a cæteris Animalibus differentia.

[n] *Paradise Lost,* book iv. 288.

[o] There is little necessity in the present day to attempt the refutation of the ridiculous opinion that man is destined to walk on all-fours. But I do so for the purpose of displaying many peculiarities of our structure.

It is almost incredible that a thinking man could have entertained it for a moment, any more than the idea of our naturally having tails. Yet this is the fact; and, in exquisite ridicule of such philosophers, Butler makes Hudibras, after proving to his mistress by his beard that he is no gelding, fruitlessly urge his erect posture in proof that he is not a horse.

> "Next it appears I am no horse,
> That I can argue and discourse,
> Have but two legs, and ne'er a tail. —
> Quoth she, That nothing will avail;
> For some philosophers of late here
> Write, men have four legs by nature,
> And that 'tis custom makes them go,
> Erroneously upon but two.

vered in a wild and solitary state, there is no well authenticated instance of one whose progression was on all-fours. If we attempt this mode of progression, we move either on the knees or the points of the toes, throwing the legs obliquely back to a considerable distance; we find ourselves insecure and uneasy; our eyes, instead of looking forwards, are directed to the ground; and the openings of the nostrils are no longer at the lower part of the nose,—in a situation to receive ascending odorous particles, but lie behind it. Our inferior extremities, being of much greater length, in proportion to the others and to the trunk, than the posterior of brutes with four extremities, even in children in whom the proportion is less, are evidently not intended to coincide with them in movement; they are much stronger than the arms, obviously for the purpose of great support: the presence of calves, which are found in man alone, shows that the legs are to support and move the whole machine; the thigh bones are in the same line with the trunk, in quadrupeds they form an angle, frequently an acute one; the bones of the tarsus become hard and perfect sooner than those of the carpus, because strength of leg is required for standing and walking sooner than strength of arm and hand for labour; the great toe is of the highest importance to the erect posture, and bestowed exclusively on mankind; the os calcis is very large, particularly at its posterior projection, for the insertion of the strong muscles of the calf, and lies at right angles with the leg; we alone can rest fully upon it, and in fact upon the whole of the tarsus, metatarsus, and toes. The superior extremities do not lie under the trunk as they would if destined for its support, but on its sides, capable of motion in every direction towards objects; the fore-arm extends itself outwards, not forwards, as in quadrupeds, where it is an organ of progression; the hand is fixed not at right angles with the arm, as an instrument of support, but in the same line, and cannot be extended to a right angle without painfully stretching the flexor tendons; the superior extremity is calculated in the erect

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As 'twas in Germany made good
B' a boy that lost himself in a wood,
And growing to a man was wont
With wolves upon all-four to hunt."

Hudibras, part ii. canto i.

posture for seizing and handling objects, by the freedom of its motions, by the great length of the fingers above that of the toes, and by the existence of the thumb, which, standing at a distance from the fingers and bending towards them, acts as an opponent, while the great toe is, like the rest, too short for apprehension, stands in the same line with them, and moves in the same direction: were our hands employed in the horizontal posture, they would be lost to us as grand instruments in the exercise of our mental superiority. Quadrupeds have a strong ligament at the back of the neck to sustain the head; in us there is no such thing, and our extensor muscles at the back of the neck are comparatively very weak.[p] They have the thorax deep and narrow, that the anterior extremities may lie near together and give more support; the sternum too is longer, and the ribs extend considerably towards the pelvis to maintain the incumbent viscera; our thorax is broad from side to side, that the arms being thrown to a distance may have greater extent of motion, and shallow from the sternum to the spine; and the abdominal viscera, pressing towards the pelvis rather than towards the surface of the abdomen in the erect attitude, do not here require an osseous support. The pelvis is beautifully adapted in us for supporting the bowels in the erect posture; it is extremely expanded, and the sacrum and os coccygis bend forwards below: in brutes it does not merit the name of pelvis; for, not having to support the abdominal contents, it is narrow, and the sacrum inclines but little to the pubes. The nates, besides extending the pelvis upon the thigh bones in the erect state of standing or walking, allow us to rest while awake in the sitting posture, in which, the head and trunk being still erect, our organs of sense have their proper direction equally as in walking or standing; were we compelled to lie down like quadrupeds, when resting during the waking state, the different organs of the face must change their present situation to retain their present utility, no less than if we were compelled to adopt the horizontal progression; and, conversely,

[p] As the head is connected with the trunk farther back in brutes than in us, the small length of lever between the occipital foramen and the back of the head, and the length of the head below the foramen, require all this power; but even in us much more upholding power than we have at the back of the neck would be required for all-four progression, as the head would no longer rest upon the spine.

were their situation so changed, the provision for the sitting posture would be comparatively useless.

While some, perversely desirous of degrading their race, have attempted to remove a splendid distinction by asserting that we are constructed for all fours, others with equal perverseness and ignorance have asserted that monkeys are destined for the upright posture. The monkey tribe, it is true, maintain the erect posture less awkwardly than other brutes with four extremities, but they cannot maintain it long, and, while in it, they bend their knees and body; they are insecure and tottering, and glad to rest upon a stick; their feet, too, instead of being spread for support, are coiled up as if to grasp something. In fact their structure proves them to be neither biped nor quadruped, but four-handed, animals. They live naturally in trees, and are furnished with four hands for grasping the branches and gathering their food. Of their four hands the posterior are even the more perfect, and are in no instance destitute of a thumb, although, like the thumbs of all the quadrumana, so insignificant as to have been termed by Eustachius, "omnino ridiculus;" whereas the anterior hands of one variety (*simia paniscus*) have not this organ. The whole length of the orang utan, it may be mentioned, falls very much short of ours.

It was anciently supposed that man, because gifted with the highest mental endowments, possessed the largest of all brains. But as elephants and whales surpass him in this respect, and the sagacious monkey and dog have smaller brains than the comparatively stupid ass, ox, and hog, the opinion was relinquished by the moderns, and man was said only to have the largest brain in proportion to the size of his body. But as more extensive observation proved canary and other birds, and some varieties of the monkey tribe, to have larger brains than man in proportion to the body, and several mammalia to equal him in this particular, and as rats and mice too surpass the dog, the horse, and the elephant, in the comparative bulk of their brains, this opinion also gave way, in its turn, to that of Sömmerring, — that man possesses the largest brain in comparison with the nerves arising from it. This has not yet been contradicted, although the comparative size of the brain to the nerves originating from it (granting that they originate from it) is not an accurate measure of the faculties, because the seal has in proportion to its nerves a larger

brain than the house-dog, and the porpoise than the orang utan.[q]

As the human brain is of such great comparative magnitude, the cranium is necessarily very large and bears a greater proportion to the face than in any other animal. In an European the vertical section of the cranium is almost four times larger than that of the face (not including the lower jaw); in the monkey it is little more than double; in most feræ, nearly equal; in the glires, solipedes, pecora, and belluæ, less. The faculties, however, do not depend upon this proportion, because men of great genius, as Leo, Montaigne, Leibnitz, Haller, and Mirabeau, had very large faces, and the sloth and seal have faces larger than the stag, horse, and ox, in proportion to the brain, and the proportion is acknowledged by Cuvier to be not at all applicable to birds. We are assisted in discovering the proportion between the cranium and face by the facial angle of Camper. He draws two straight lines, the one, horizontal, passing through the external meatus auditorius and the bottom of the nostrils; the other, more perpendicular, running from the convexity of the forehead to the most prominent part of the upper jaw. The angle which the latter,—the proper facial line,—makes with the former, is greatest in the human subject, from the comparative smallness of the brain and the great developement of the mouth and nose in brutes. In the human adult this angle is about from 65° to 85°; in the orang utan about from 55° to 65°; in some quadrupeds 20°; and in the lower classes of vertebral animals it entirely disappears.

Neither is it to be regarded as an exact measure of the understanding, for persons of great intellect may have a prominent mouth; it shows merely the projection of the forehead, while the cranium and brain may vary greatly in the size of other parts; three-fourths of quadrupeds, whose crania differ extremely in other respects, have the same facial angle; great amplitude of the frontal sinuses, as in the owl and hog, without any increase of brain, may increase it, and for this reason Cuvier draws the facial line from the internal table of the frontal bone.

In proportion as the face is elongated, the occipital foramen lies more posteriorly; in man consequently it is most forward. While in man it is nearly in the centre of the base of the cranium, and horizontal, and has even sometimes its anterior margin

[q] See Gall, l. c. t. ii. p. 281. sqq.

elevated; in most quadrupeds it is situated at the extremity of the cranium obliquely, with its posterior parts turned upwards, and is in some completely vertical. On this difference of situation, Daubenton founded his occipital angle.[r] He drew one line from the posterior edge of the foramen to the lower edge of the orbit, and another, in the direction of the foramen, passing between the condyles and intersecting the former. According to the angle formed, he established the similarity and diversity of crania. The information derived from it in this respect is very imperfect, because it shows the differences of the occiput merely. Blumenbach remarks that its variations are included between 80° and 90° in most quadrupeds which differ very essentially in other points.

The want of the ossa intermaxillaria has been thought peculiar to mankind. Quadrupeds, and nearly all the ape tribe, have two bones between the superior maxillary, containing the dentes incisores when these are present, and termed ossa intermaxillaria, incisoria, or labialia. But these do not exist universally in them.[s] Man only has a prominent chin: his lower jaw is the shortest, compared with the cranium, and its condyles differ in form, direction, and articulation, from those of any brute: in no brute are the teeth arranged in such a close and uniform series; the lower incisores, like the jaw in which they are fixed, are perpendicular, — a distinct characteristic of man, for in brutes they slope backbackwards with the jaw bone; the canine are not longer than the rest, nor insulated as in monkeys; the molares differ from those of the orang utan and of all the genus simia by their singularly obtuse projections.

The slight hairiness of the human skin in general, although certain parts, as the pubes and axillæ, are more copiously furnished with hair than in brutes; the omnivorous structure of the alimentary canal; the curve of the vagina corresponding with the curve of the sacrum formerly mentioned, preventing woman from being, as brute females are, retromingent; the peculiar structure

[r] *Mémoires de l'Académie des Sciences de Paris.* 1764.

[s] In a chimpanzee that died at Exeter Change a few years ago, the statement of Tyson and Daubenton was verified, — that this black ape has no intermaxillary bone. The red-haired variety (*Simia Satyrus*) has it, and is said to be destitute of nails on the hind thumbs and of ligamentum teres at the head of the os femoris, both which structures this chimpanzee possessed. The Satyrus is therefore not so near the human subject as the Troglodytes. In a simia satyrus, however, lately dissected at the Zoological Gardens, the hind thumbs possessed nails. *Proceedings, &c.* Nov. 23. 1830.

of the human uterus and placenta; the length of the umbilical chord and the existence of the vesicula umbilicalis until the fourth month; together with the extreme delicacy of the cellular membrane; are likewise structural peculiarities of the human race. The situation of the heart lying not upon the sternum, as in quadrupeds, but upon the diaphragm, on account of our erect position, — the basis turned not, as in them, to the spine, but to the head, and the apex to the left nipple; the absence of the allantois, of the panniculus carnosus, of the rete mirabile arteriosum, of the suspensorius oculi; and the smallness of the foramen incisivum, which is not only very large in brutes, but generally double, though not peculiarities, are striking circumstances.

Man only can live in every climate [t]; he is the slowest in arriving at maturity, and, in proportion to his size, he lives the longest of all mammalia; he only procreates at every season, and, while in celibacy, experiences nocturnal emissions. None but the human female menstruates.

Man, thus distinguished from all other terrestrial beings, evidently constitutes a separate species. For "a species comprehends all the individuals which descend from each other, as from a common parent, and those which resemble them as much as they do each other [u];" and no brute bears such a resemblance to man.

The knowledge of all the objects and laws of nature might be supposed to be signified by the term physiology, derived as it is from φύσις, nature, and λόγος, a discourse. But the term is restricted to vegetables and animals, and indeed solely to their functions. The knowledge of their structure is designated ANATOMY; the knowledge of their functions PHYSIOLOGY.

Both anatomy and physiology are divided into vegetable and animal; and the latter again into brute, or comparative, and human. The subject of the present work is HUMAN PHYSIOLOGY: but the functions of brutes and vegetables will frequently be mentioned.

[t] Blumenbach accounts for this, and I think justly, by the two-fold operation, of our intellect (l. c. § 18. p. 54.), and of the more accommodating nature of our frame (l. c. § 17.).

[u] Cuvier, *Discours Préliminaire aux Recherches sur les Ossemens Fossiles des Quadrupèdes.*

CHAP. II.

GENERAL VIEW OF THE CONSTITUENTS OF THE HUMAN BODY.

THE *ultimate* PRINCIPLES of animal bodies, forming the distinct compounds, whether gases, fluids, or solids, are:—

Hydrogen,
Carbon,
Oxygen,
Azote,
Chlorin, iodin, fluorin?
Sulphur,
Phosphorus,
Potassium,
Sodium,
Calcium,
Magnesium, silicium?
Manganese?
Iron,
Copper?[a]

The *proximate* PRINCIPLES, or distinct chemical compounds of animal bodies, are:—

Albumen, Fibrin, Colouring matter of blood, Curd, Fatty matter, { olein, stearin, Gelatine, obtained from various textures by boiling, Matters found in the bile,—cholesterin, erythrogin, asparagin, picromel? Mucus, and probably some other products of glands at present but little understood,	Subject to great variety in different animals, &c.

[a] The ultimate principles of vegetables may be considered the same as those of animals.

Urea,
Cystic oxide, xanthic oxide,
Uric acid,
Erythric acid?
Purpuric acid,
Oxalic acid,
Acetic acid,
Lactic acid,
Butyric acid,
Formic acid,
Benzoic acid,
Sulpho-cyanic acid,
Sugar of milk,
Sugar of diabetic urine,[b]

Not subject to variety; uniform in all instances.

[b] Vegetable proximate principles are very numerous: the following may be considered the chief: —

Sugar,
Starch,
Lignin,
Gum, mucus, jelly,
Extractive, colouring matters, bitter principles,
Gluten
Oils, fixed and volatile,
Resins,

All subject to endless variety as occurring in different plants.

The following are constant in their character, or are peculiar to certain vegetables.

Various acids — Oxalic, citric, tartaric, malic, moroxylic, gallic, laccic, kinic, boletic, prussic, meconic, benzoic, &c.

Various alkaline bodies — Quinina, cinchonina, morphina, strychnina, brucina, delphina, picrotoxina, atropia, veratrina, hyoscyamina, &c.

Indigo,
Tan,
Suber,
Caoutchouc,
Wax,
Asparagine, ulmine, inuline, fungine, polychroite, hæmatine, nicotine, pollenine, emetine, sarcocol, olivile, medulline, lupuline, cathartine, piperine, daphnine, salicine, populine, digitaline, santonine, cafeine, hordeine, elatine, &c, &c.

The *ultimate* SOLIDS, which these principles are said to compose, are, the cellular fibre, the muscular fibre, and the nervous fibre.[c]

The *proximate* SOLIDS, said to be composed of these primary, or rather ultimate, or elementary solids or tissues, and forming the different organs, have been variously specified.[d]

Dr. Carmichael Smyth, in an admirable paper upon inflammation, considered that disease according to the structures which it affects, — the skin, cellular membrane, serous membranes, mucous membranes, and muscular fibres.[e] Dr. Pinel, some years afterwards, adopted this arrangement[f]; and Bichat at length suggested that all diseases might be considered in this manner, and he distributed the proximate solids into twenty-one kinds:—

1. Cellular,
2. Nervous, of animal life,
3. Nervous, of organic life,
4. Arterial,
5. Venous,
6. Exhalant,
7. Absorbent, with its glands,
8. Osseous,
9. Medullary,
10. Cartilaginous,
11. Fibrous (tendino-fibrous),
12. Fibro-cartilaginous,
13. Muscular, of animal life,
14. Muscular, of organic life,
15. Mucous,
16. Serous,
17. Synovial,
18. Glandular,
19. Dermoid,
20. Epidermoid,
21. Pilous.[g]

[c] See Appendix, by Dr. Copeland, to his translation of Richerand's *Nouveaux Elémens de Physiologie*, p. 553. sqq. Many writers have asserted the globular composition of various parts of the animal and vegetable frame. Lately, the cellular, muscular, and nervous structures were described as consisting of globules, and some novel views presented, by Dr. M. Edwards. (*Archives Générales de Médecine*, t. 3. Paris, 1823.) But the whole results have been denied by Dr. Hodgkin and Mr. Lister, who repeated the examination with a much superior microscope. *Philos. Magazine*, August, 1827.

Another author professes to have made still more minute discoveries than Dr. Edwards. Dutrochet, *Recherches, Anatomiques et Physiologiques, sur la Structure Interne des Animaux et Végétaux.*

[d] "The ancients divided the body into *similar* or homogenous parts, — those consisting of particles similar to one another, as the bones, cartilages, muscles, tendons, &c.; and *dissimilar*, — those composed of the similar, as the head, trunk, limbs," &c.

[e] *Medical Communications, by a Society for the Promotion of Medical Knowledge*, vol. ii. 1790. Read to the Society, Jan. 1788.

[f] *Nosographie Philosophique*, 1797.

[g] *Anatomie Générale*, t. i. p. lxxx.

This arrangement, Dr. Rudolphi remarks, is physiological rather than anatomical, and he distributes them into eight classes only: —

Cellular,	Tendinous,
Horny,	Vascular,
Cartilaginous,	Muscular, and
Osseous,	Nervous.[h]

The *ultimate* and *proximate* FLUIDS of the body, generated by its functions, whether for its own use, or for elimination from it, may perhaps be viewed as,

Aqueous,	Oleaginous,
Mucous,	Bilious,
Albuminous,	Urinous,
Fibrinous,	Seminal.

The first fluid is that derived from external matter, — the chyle; then that into which this is formed, and which is distributed through the system, — the blood; then the various fluids produced from this.

To show the preponderance of the fluid over the solid matter of the body, Blumenbach states that he possesses the entire, but *perfectly dry*, mummy of a Guanche, or aboriginal inhabitant of Teneriffe, presented to him by Sir Joseph Bankes, which, with all its muscles and viscera, weighs but seven pounds and a half.[i]

[h] *Grundriss der Physiologie*, 68.

[i] *Instit. Physiol.* sect. 1. edit. 4. Gottingæ, 1821.

CHAP. III.

GENERAL VIEW OF THE ORGANS, FUNCTIONS, AND POWERS OF THE HUMAN BODY.

THE proximate solids are made up into various *organs;* and the operation of an organ is termed its *function.*

While a part is performing its functions, and even while it only remains in a condition fit for the performance of its functions, changes of its constituent particles go on; indeed, many functions are in a great measure but chemical changes. The separation of one portion of matter must occasion the addition of another to be necessary. Hence organs are framed for receiving matter from without, and for changing it variously, so as to fit it to become a portion of the fluids of the body; for distributing it through the body, and rendering it a part of the body; and for the separation and elimination of those particles which in the course of the chemical changes must quit the system. We thus observe organs of reception, assimilation, circulation, nutrition, secretion, and excretion. As individuals last but a limited time, the species is preserved by the generation of new beings from individuals. Organs of generation are therefore framed; but this function is merely circulation, secretion, excretion, and nutrition.

We perceive external objects and circumstances; are conscious of much within ourselves; we think, desire, and exert volition. The organs of these functions are termed the nervous system. It exists in mass, and is also ramified throughout the frame. Impressions upon the extremities of its ramifications, as well as upon these in their course, are conveyed along them to the mass, where they are perceived; and the mandates of the will are conveyed from the mass along the ramifications to fleshy organs of motion, termed muscles; and the influence of emotion is also conveyed from the mass along the ramifications to every part.

The ancients arranged all these functions in four classes:— The *vital*, or those constantly necessary to life, comprising respiration and the action of the heart: the *natural*, or those by which the body is nourished: the *animal*, or those which principally distinguish animals from vegetables, viz. sense, consciousness, desires, thought, volition: and the *genital*.

The functions are now generally arranged in two classes: the *animal*, constituting one peculiar to animals; and the vital and natural, united into another, common to vegetables and animals, under the title of *organic* or *vital*. The generative, relating in their object to the species rather than to the individual, and of but temporary duration, are thrown into a separate and inferior division, but in fact, except the animal passion, are part of the organic.

We owe the revival of this classification, and our knowledge of the characteristics of each class of functions, to Dr. Wilson Philip [a] and Xavier Bichat [b]; although the latter, from having published a work expressly on the subject, has received the whole honour, both in Great Britain and on the Continent.

The *animal* functions prove us feeling, thinking, and willing beings: they are the actions of the senses which receive impressions; of the brain which perceives them, is conscious, desires, reflects, and wills; of the voluntary muscles which execute the will in regard to motion; and of the nerves which are the agents of transmission: the brain is their central organ. The *vital* or *organic* functions are independent of mind, and give us simply the notion of life: they are digestion, circulation, respiration, exhalation, absorption, secretion, nutrition, calorification: the heart is their central organ.

The organs of the animal functions are double and correspondent, there being on each side of the median line of the body either two distinct organs, as the eyes, ears, extremities; or two correspondent halves, as is the case with the brain, spinal marrow, nose, tongue, &c.

[a] *Treatise on Febrile Diseases*, ch. iii. sect. 3. First edition. 1799. *Paper read to the Royal Med. Society of Edinburgh*, 1791 *or* 1792, *and inserted in its Records. Essay on Opium.* 1795. *Edinburgh Med. and Surgical Journal*, July, 1809. p. 301. sq.

[b] *Recherches Physiologiques sur la Vie et la Mort.* 1805.

The organs of the vital or organic functions are in very few instances double, or situated with their centres in the median line and possessed of symmetrical halves; witness the heart, stomach, liver. There are, indeed, two kidneys, but they continually differ in size, figure, and situation: the two lungs are very dissimilar.[c]

Hence Bichat infers, that in the animal functions a harmony of action in each organ, or in each half of the organ, is indispensable to perfection, when both organs or sides act together; and that if such harmony do not occur, it is better for one organ or one half to act alone. This certainly appears true of the eye, and ear, and even of the brain. It certainly does not hold good in the actions of the voluntary muscles, nor in the operations of the brain or spinal marrow in willing those actions. From the duplicity of the organs it also happens that one side may cease to act without detriment to the function of the other; while, in the vital or organic class, no harmony of action is possible, and the derangement of any one part of an organ generally affects the whole of it, — an obstruction in the colon disturbs the functions of all the alimentary canal.

The animal functions experience periodical intermissions — sleep. The organic or vital continue incessantly, suffering merely remissions: — the blood constantly circulates, the perspiratory fluid is constantly secreted, the stomach has no sooner digested one meal than we commit another to it, yet we shall hereafter

[c] As the nerves of one perpendicular half of the body are connected with one half of the brain or spinal marrow, it is not surprising that we often see a loss of motion or of sense, or the reverse, viz. spasms or convulsions, or even an excess of sensibility, in one perpendicular half of the body. But we have examples of ague affecting only one perpendicular half of the body (*Ephemer. Nat. Curios.* and *Mémoires de Montpellier,* 1827): of persons who sweated on one perpendicular half only, (*Ephemer. Nat. Curios.* Dr. Abercrombie on *Diseases of the Brain and Nerves* (the line on the face was distinctly marked), p. 284. Dr. Andral, *Clinique,* vol. i. p. 477.): and of a child that became pale and emaciated in one perpendicular half, while the other remained plump and healthy. (Dr. Falconer, *Memoirs of London Med. Soc.* vol. ix.) Still, as we have paralysis and convulsions also in a horizontal half, so instances are on record of ague affecting a horizontal half (*Journal de Médecine,* t. xxiv. p. 60. January, 1766); and of one horizontal half sweating (Andral, *ib.*): and as we have also examples of paralysis and convulsions affecting a limb only, so ague is said sometimes to have seized but a single limb. (Dr. Macculloch, *on Marsh Fever and Malaria.*)

see that the actions of the heart, lungs, &c., have intervals of remission.

The animal functions are much influenced by habit; the vital or organic are considered by Bichat as removed from its influence. The power of habit over our sensations and voluntary motions is manifest, — the more frequently an object is applied to our organs of sense, the less intense is the sensation produced by it; and the more frequently we perform an act of volition, the more readily is it performed. Yet I think the force of habit equally great over the organic functions. The operation of food and of all descriptions of ingesta is most remarkably modified by habit; through it poisons become comparatively innocuous, and divers bear a long suspension of respiration.

Bichat regards the passions as directly influencing the organic functions only, and springing from the state of the organs of that class. Here he is to me perfectly unintelligible. Vexation indeed disturbs the stomach, and fear augments the quantity of urine; but does not vexation equally and as directly disturb the mind, — confuse the understanding, and occasion heat and pain of the forehead? Are not, in fact, the passions a part of the mind? — a part of the animal functions? They powerfully affect, it is true, the organic or vital functions, but this shows the close connection merely between the two classes of functions. [d]

This connection is conspicuous in respiration, the mechanical part of which belongs to the animal functions, the other to the organic; and in the alimentary functions, in which the food is swallowed and the fæces rejected by volition, and digestion, &c. performed, independently of our influence, by the powers of simple life. So close indeed is this connection, that every organ of the animal class is the seat of organic functions; — in the voluntary muscles, the organs of sense, and even in the brain, circulation, secretion, and absorption are constantly carried on. This connection is likewise apparent in the property of sensibility. In the language of Bichat, there are *animal sensibility and contrac-*

[d] Bordeu, Buffon, Cabanis, and the anatomist Reil, placed the passions in the thoracic and abdominal viscera, &c.; the two first in the diaphragm particularly. Gall has shown the absurdity of these authors in his *Fonct. du Cerveau*, t. ii. p. 93. sqq. We might as well consider the cheeks the seat of the feeling of shame, because in shame we blush. Hippocrates opposed such absurdities in his day. "The heart and præcordia," says he, "feel acutely, but have not the least intelligence: the *brain* is the cause of all these things." *De Morbo Sacro.*

tility, and *organic sensibility and contractility*, besides the common extensibility of matter, which he terms *extensibilité de tissu*, and common contractility upon the removal of distension, — *contractilité par défaut d'extension*, which, indeed, is greater during life than afterwards.[e] *Animal sensibility* is accompanied by a perception

[e] The following is Bichat's table of the properties of the living body : —

	Classes.	*Genera.*	*Species.*	*Varieties.*	
Properties.	1 Vital	1 Sensibility	1 Animal		
			2 Organic		
		2 Contractility	1 Animal		
			2 Organic	1 Sensible	Such as the motion of the *heart* and *alimentary canal.*
				2 Insensible	Such as the motion of the *capillaries.*
	2 Structural	1 Extensibility			
		2 Contractility			

Although these are the general properties of the living frame, and sensibility, or more properly excitability, is at the bottom of all the other vital or organic properties except the active power of contraction, yet each part has also some peculiarity, altogether inexplicable,—not in the least, I think, to be accounted for on Bichat's supposition of each part possessing a certain *degree* of organic sensibility in relation to its fluids. What causes the vessels of muscle to produce muscle; of bone, bone; of membrane, membrane; what causes the secreting vessels of the liver to form bile, and of the testes semen, we know not. The causes of these circumstances are called by Blumenbach, after Bordeu, *vitæ propriæ;* but it must be carefully remembered, that this expression simply denotes an unknown cause of a fact, and affords no explanation.

Feeling (I use the word for want of another to embrace consciousness and perception) is in the same manner at the bottom of all the mental properties except the active power of willing, but it alone will not explain them. All matter is probably the same; but its *modifications* likewise are so various, that at present we are compelled to speak of distinct kinds of matter.

The operation of agents on the system is analogous. As far as they all affect the living solid, they may be all called stimuli; but they differ in something more than *degree* of stimulus. Each affects particular parts more than others; each affects in a peculiar way; some directly depress life, and many occasion opposite results in different parts; some produce specific diseases, in which the composition of the fluids may be altered; and here occasionally the specific disease produced is contagious.

When organic sensibility is heightened in one part, it sinks in another, and *vice versâ;* unless the change of it should be such as to extend generally, and even then it is still frequently found in the opposite state in some particular part: *v. c.* we notice coldness and paleness of the feet, and heat and fulness of the head,

in the mind, as in seeing, hearing, tasting, smelling, feeling: *animal contractility* is excited by the volition of the mind conveyed to the voluntary muscles by means of the nerves. *Organic sensibility* is attended by no perception, and is followed by con-

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together; blisters relieve internal inflammation, and irritate the more difficultly in proportion to the violence of the internal disease. The same phænomena are observable in animal sensibility and in the mind at large: —

> " Tut, man! one fire puts out another's burning,
> One pain is lessen'd by another's anguish;
> Turn giddy, and be holp by backward turning;
> One desperate grief cures with another's languish;
> Take thou some new infection to thy eye,
> And the rank poison of the old will die."
>
> SHAKSPEARE. *Romeo and Juliet*, act i. sc. ii.

The effect of vicissitudes of temperature, and a large number of other pathological phænomena, are principally explicable on the derangement of the balance of excitability, and for the most part, *consequently*, of circulation.

Notwithstanding it is a general law that the effects of an agent diminish the more frequently it is applied, and *vice versâ*, as shown on the one hand, in the large quantities of spirituous liquors which persons at length bear, and on the other by the violent inflammation excited by the application of warmth to parts exposed to intense cold; yet, if a stimulus is applied so energetically as to leave the sensibility heightened, especially if to the point of inflammation, its subsequent power is greatly increased. Immense potations of spirituous liquors may gradually be borne, but if the increase is too great, the sensibility of the stomach may become such that a single glass will prove violently irritating.

The general law, to which the effects of agents, in proportion to their previous application, is referable, appears to be this; — that an agent acts according to the *difference* between its strength and the strength of the former application. Thus, if the right hand be immersed in water of 30°, and the left in water of 50°, and both are removed to water of 70°, the effect of the water at 70° upon the right hand will be greater than upon the left, on account of the difference between 30° and 70° being greater than between 50° and 70°; and this explains the glow of the cold bath, as, during immersion, there is less stimulus, and, on emerging, the temperature of the atmosphere, and the re-admitted blood into the superficial vessels, though stimuli absolutely of the same strength as before immersion, are, *comparatively*, more powerful than what the system experienced during immersion.

The specific action of one agent frequently prevents or destroys that of another: *v. c.* small-pox and measles very rarely occur together; the former disease is frequently prevented for ever by the cow-pock; bark cures the effect of marsh

traction totally independent of the will: — the heart is said to feel (physiology has no proper term for the idea, but *excitability* would answer the purpose) the stimulus of the blood, and, without our influence, forthwith contracts; the lacteals to feel the stimulus of the chyle without our knowledge, and they then propel it

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miasmata. It in some cases destroys its own power in future, as is exemplified in those diseases which occur usually but once during life.

These observations on rare and frequent agency may relate to agency in general or by particular agents. A very high or low excitement may influence the effects of all subsequent stimuli; but the rare or frequent application of a particular agent in less intensity may influence its own effects only, as is exemplified in the acquired capability of smoking or taking snuff, while other vapours or powders affect no less than usual.

While moderate excitement is necessary to maintain action and excitability, and excitement by one stimulus, within due limits, augments the effects of another, violent excitement wears out the power, and, very violent, may suddenly destroy life altogether: according to the verses,

> Nutritur ventis, ventis extinguitur ignis,
> Lenis alit flammas, grandior aura necat.

Dr. John Brown, seizing the undeniable general facts respecting the effect of rare or frequent application upon the power of stimuli, and naming all agents stimuli, founded a system of pathology and practice at once absurd and destructive. (*Elementa Medicinæ.*) Exhaustion, from excess of stimulus, he termed direct debility; torpor, from deficiency of stimulus, indirect debility; and however inflammatory a disease, if it arose from a stimulus, it was to be treated by violent stimuli, to prevent the excitability from falling too low.

In the first place, he abused the word stimulus, by confounding it with the word agent, forgetting what has been just advanced respecting the peculiar properties of every agent, — that some depress, and thus, though agents, are not stimuli; and some affect different parts differently; and some have a specific power upon certain parts and certain diseases, and against other agents.

In the second place, he forgot what has been just said respecting the necessity of a certain degree of excitement to maintain excitability; the effect of one stimulus, within due limits, of increasing the effect of others; and the fact of a stimulus producing so much excitement, that morbid sensibility occurs, far less stimulus than was at first applied causing ten times the effect, and this being reducible only by lessening all stimuli, — the temperature, the quantity of blood, &c., and stimulating distant parts. He forgot, also, the effect of sympathy and specific action.

His error was in keeping in view some general laws, which all know and acknowledge, to the exclusion of others of at least equal importance.

without our assistance.[f] But although we never acquire the least direct voluntary power over the actions of organic contractility,— over the peristaltic motion of the intestines or the contractions of the heart, yet every organ of the organic functions may have its organic sensibility heightened into animal sensibility, as inflammation, for instance, of the pleura and the joints, daily demonstrates; indeed, in some organs of that class of functions, we invariably have sensation; — the stomach is the seat of hunger; in the lungs we experience an uneasy sensation nearly as soon as their air is expelled.

The nerves of the animal functions run to the brain or spinal marrow; those of the organic chiefly to ganglia; but, as might be expected, the two nervous systems have abundant communications.

The animal functions have not only a shorter existence than the organic, from their necessity of alternate repose[g], but they flourish for a shorter duration,— they do not commence till birth, they decline, and, in the natural course of events, terminate, earlier, *v. c.* the organs of sense and the mental faculties fail before the action of the heart and capillaries. But the decay of the animal functions must, in truth, be only the consequence of the decay of the organic, because there are fundamentally in every part organic functions,— circulation, nutrition, &c.; and the perfect performance of these in the organs of the animal functions is indispensable to the perfect performance of the animal functions. Hence the impairment of these organic functions, even to a small extent, must derange or diminish the animal functions, and the decline of the latter is really owing to the decline of the former, although these still remain vigorous enough to appear unimpaired.

[f] There is no proof of feeling. There can be no feeling. We see them act in consequence of the stimulus, and say they feel. The expression is only admissible figuratively, but as all figurative terms in physiology are continually accepted literally, and establish the most absurd notions, especially among the vulgar, it had much better be explained by a mere expression of the fact, by the word *excitement*.

[g] It is said that the heart has the same repose as the brain, the auricles and ventricles acting in succession, and a pause occurring before their action is renewed. The function, however, of the heart as a whole organ, constantly goes on; while that of the brain, at least if it is *only* an organ of the mind, entirely intemits in sound sleep.

We thus find in every living system a class of functions, not in themselves dependent upon mind, as perfect in the vegetable as in the animal, and pervading every part of the system. In animals there further exist certain parts which, when endowed with the common life of other parts, — with the organic properties, — are able to perform peculiar functions which give us the notion of mind: the organ of these functions is termed brain, and, by means of nerves and medullary prolongations, it maintains a correspondence with the whole machine, influenced by and influencing the most distant parts.

The ORGANIC FUNCTIONS depend on LIFE, in the proper acceptation of the word. The word life should be regarded, like the word attraction or repulsion, as merely an expression of a fact. In this point of view it may be as easily defined as any other expression. By LIFE we generally mean the power of organised matter to preserve its particles in such chemical relations as to prevent other chemical relations from inducing disorganisation, or even to increase or decrease by internal appropriation and separation[h]; to produce peculiar matters for its own purposes; to preserve, in some measure, a temperature distinct from that of the surrounding medium; to move certain parts of itself sensibly (as muscles) or insensibly (as the capillaries) independently of mere impulse, attraction, or repulsion: or if not organised (as the fluid which becomes the embryo, the blood,) the power of matter produced by an organised body endowed with the properties above mentioned, to resist the ordinary chemical influences, and even directly form (as the embryotic fluid) an organised system so endowed, or directly become, (as the fibrin, when it is secreted from the blood or blood is effused, becoming vascular, and its new vessels inosculat-

[h] So striking is this, that Stahl and his followers referred their notion of life to this antiseptic property, and while he said, " Life is formally nothing more than the preservation of the body in mixture, corruptible, indeed, but without the occurrence of corruption," Junker said, " What we call life is the opposite of putridity."

Chemical affinities are not destroyed by life, but only so brought to play that decomposition is not their result. Without the operation of chemical affinities the composition of the body could not exist, nor many of its functions, as respiration, secretion, &c., take place. The physical properties of matter are equally indispensable. Cohesion, gravity, hardness, softness, and fluidity are essential, in different parts; elasticity performs an important part in many functions, as in respiration and the rise of the epiglottis; the laws of light and sound are indispensable to the functions of the eye and ear.

ing with those of adjoining parts,) the organised substance of an already formed system so endowed.

That fluids as well as solids are susceptible of life, I cannot doubt. There is no reason why they should not be so, although a person who has not thought upon the subject may be as unable to conceive the circumstance as a West Indian to conceive that water may by cold become solid. It is impossible to deny that the male or female genital fluid, or both, either alone or when united, are alive, because from their union, or from one when influenced by the other, a living being is produced which partakes of the vital qualities of each parent. Accordingly Blumenbach, in his *Commentatio de vi vitali sanguini deneganda*, grants both male and female genital fluids to be alive[i], notwithstanding that he fancies his victory over the defenders of the blood's life so complete, that, like that of the unfortunate Carthaginian Dido, he says, "*in ventos vita recessit.*" It is as easy to conceive the blood to be alive as the genital fluids.[k]

Many facts adduced as arguments of its life are certainly expli-

[i] In universum sane post omnia quæ super hoc argumento sive meditando sive experiundo hactenus elicere licuit, nulli humorum nostri corporis genuina vis vitalis tribuenda videtur, si unice a genitali utriusque sexus latice discesseris, utpote cui jam ante quam uterino cavo exceptus et intime mixtus in fœtus formationem abit, vitales inhærere vires formativas, præter alia paterni vultus in nepotes propagata similitudo, aliaque id genus phænomena haud infitianda demonstrare videntur." *Comment. Soc. Reg. Societ. Gotting.* vol. ix. p. 12.

[k] The doctrine of the life of the blood was maintained by Critias and his sect among the ancients (Aristotle, *De anima,* cap. 2.), Harvey (Exercit. L. *De Generationis ordine,* &c.), Glisson (*De ventriculo et intestinis*), and Albinus. (Blumenbach's *Commentat.* l. c.) I am surprised that Moses should have been adduced by Harvey as authority for this opinion. When he says (*Leviticus,* ch. xvii. 11. 14.), "For the life of the flesh is in the blood," — "For it is the life of all flesh," — he can only mean, that, when it is withdrawn, life ceases, — that it is necessary to the life of animals. He also says, (v. 14.) "the blood of it is FOR the life thereof." The construction which would make Moses assert that the blood is alive, involves the absurd assertion that the blood only is alive. Indeed, before the time of Moses, the expression was used to Noah. In *Genesis* (ix. 4.) we read, "Flesh with the life thereof, which is the blood thereof, shall you not eat." The whole of the matter appears to be, that the Jews, like other neighbouring nations, were in the habit of tearing limbs and cutting flesh from living animals, and eating these portions raw. Saul's army after a battle did this. (1 *Samuel,* xiv. 32, 33.) To prevent this horrid cruelty, they were forbidden to eat flesh before the animal had been drained of its blood, and thus deprived of life; and what is, in our own version of the Bible, rendered, "flesh with the life thereof, which is the blood

cable without such a supposition. Its freedom from putrefaction while circulating may be owing to the constant renovation of its particles; for the thinness of hybernating animals at the end of their torpid season shows it has received accessions even in tnem, and this from the absorption of fat. Its inability to coagulate after death from arsenic, opium, and some other narcotics, and from lightning and electricity (though Sir C. Scudamore found it to coagulate as usual in the latter case), from hard running, anger, or a blow on the stomach, all three of which deprive the muscles of their usual stiffness, may depend upon chemical changes. The admixture of opium with the blood has been said to prevent its coagulation, and this by destroying its life. But Sir C. Scudamore found that the admixture of prussic acid and belladonna, both strong poisons, has no such effect, and that many mere salts, as common salt, weaken or prevent its coagulation, and these are not likely to kill it, but to act chemically. Its accelerated coagulation by means of heat, when frozen by cold, and some other circumstances, and the reverse, were believed to depend upon an affection of its vitality, but are, perhaps, referable to some chemical effect. Its earlier putridity when drawn from young than from old persons may arise from its inferior qualities. Parts die if deprived of a supply of blood; yet, though necessary as a material and agent to maintain the life of parts, it is not, therefore, necessarily itself alive. But the circumstance of its freezing more readily, like eggs, frogs, snails, &c., when once previously frozen (which change may be supposed to have exhausted its powers[l]), is, if really the case, an argument in favour of its life, as these are certainly endowed with life. The organisation of extravasated blood[m], and the inosculation of new vessels with those of surrounding parts, shows[n] that the solidified lymph is now endowed with

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thereof," is said to be rendered by the best interpreters, "flesh or members torn from living animals having the blood in them." See Bruce, *Travels to discover the Source of the Nile*, vol. iii. p. 297.

[l] Corrie, *on the Vitality of the Blood*, p. 45.

[m] J. Hunter, *Treatise on the Blood, &c.* p. i. ch. 1.

[n] Dr. John Thomson believes, that, when blood has been effused between divided surfaces, its coagulum is absorbed, and *secreted* lymph only coagulates and becomes vascular. *Lectures on Inflammation*, p. 214. Yet at page 216. he does not deny the occurrence.

life; and one may more easily believe it to have been alive in the mass of blood, than that it should have acquired vitality after its effusion. Indeed Sir Everard Home declares that a coagulum of blood becomes vascular out of the body, and may be injected[o]; but if the vessels are formed by the mere extrication of carbonic acid gas, as he contends, their mere formation is no proof of life.

John Hunter believes that the chyle is alive, and some that vivification commences in the stomach; and Albinus grants life even to the excrement. But the excretions must be regarded as dead matter, useless and foreign to the system, and they all run with the greatest rapidity into decomposition. In operating for retention of urine, the surgeon finds this fluid abominably fœtid; the fæces become so when not discharged in due time; and the neglect of washing the surface is the source of filth and disease.

The essential nature of life is an impenetrable mystery, and no more a subject for philosophical enquiry than the essential nature of attraction or of heat. To attempt explaining the phenomena of life by a vital fluid is only increasing the intricacy of the subject by an unfounded *hypothesis*, and always reminds me of Mr. Dugald Stewart's remark,—"That there is even some reason for doubting, from the crude speculations on medical and chemical subjects which are daily offered to the public, whether it (the proper mode of studying nature) be yet understood so completely as is commonly imagined, and whether a fuller illustration of the rules of philosophising, than Bacon or his followers have given, might not be useful even to physical enquirers."[p] We see matter in a certain state possessed of a certain power which we term life, and the object of physiology is merely to observe its effects, just as it is the object of chemistry to observe the circumstances of the affinity of different bodies and of physics to observe other phenomena of matter, without vainly speculating on the essence of affinity or the essence of matter, to comprehend which our faculties are, in their nature, incompetent. By attributing life, the power of attraction, &c. to subtle and mobile fluids, we not only do not advance a single step, for we have still to explain what these fluids are, and how *they* obtain *their* powers, just as we had before in regard to common matter; but we make the addi-

[o] *Phil. Trans.* vol. cviii. p. 188. sq.

[p] *Elements of the Philosophy of the Human Mind*, vol. i. p. 8.

tional mysteries of their being united with ordinary matter, and so united that life appears a power possessed by *it*. The editors of a medical review have in vain searched John Hunter's works for such an *hypothesis*[q], and Mr. Lawrence has had no better success[r], so that I apprehend his meaning has been misunderstood by those who constitute him its patron.[s] Granting for a moment that *life* depends upon a peculiar, fine fluid, we have still to account for *mind*, because life is not mind, — a cabbage is as much gifted with life as the wisest man. Yet those whose faith makes life a subtle fluid strangely imagine that the doctrine of a soul is thereby advanced. The life of a brute requires a subtle fluid as much as the life of a man, and of a cabbage as much as the life of a brute.

We have reason to believe that life never originates, but began at the creation, and is communicated to assimilated matter, and propagated from parent to offspring. It is the property of organised systems, producing various effects by various kinds of organisation, but is not quite peculiar to organised matter, because capable of being possessed by matter in a fluid state.[t]

[q] *Annals of Medicine and Surgery*, 1817, p. 373. In the *Treatise on the Blood*, (p. 89. sq.) John Hunter says, " Life is a *property* (not a subtle fluid) we do not understand." This property he conceives to reside in a certain matter similar to the materials of the brain; diffused through the body and even contained in the blood. " The brain," he adds, " is a mass of this matter, not diffused through any thing, for the purpose of that thing, but constituting *an organ* in itself." This *materia vitæ* is, therefore, not *subtle*, but pretty solid, and no other than medullary matter; and Vauquelin says he has discovered a fatty matter in the blood, and which M. Chevreuil thinks he proves to be the same as the substance of the brain and nerves. But the subtle-fluidists would not tolerate *gross fatty* matter, and J. Hunter calls life a *property*.

[r] *Lectures on the Physiology, Zoology, and Natural History of Man*, p. 84.

[s] J. Abernethy, *Lectures delivered before the Royal College of Surgeons.* 1814.

[t] As the fluids which form the embryo must be endowed with life, organisation cannot be the cause of life; but in truth, organisation is the effect of life, although when produced it becomes an instrument of life. The erroneousness of the French doctrine, that " life is the result of organisation," was refuted in the *Annals of Medicine and Surgery*. (1816, Sept. pp. 346. 386.) The error appears to have arisen in some measure from the want of definition, — the word life being used sometimes properly for the power, sometimes improperly for the result. Even if the result of life, — the functions of a part, should be called its life, life could not be said to be the result of organisation, but of a power to which organisation is an instrument. The Greeks had distinct appellations for the cause and the result; the former they termed ψυχὴ; the latter, ζωὴ.

The ANIMAL FUNCTIONS demonstrate MIND. This is seated in the brain, to which the spinal marrow, nerves, and voluntary muscles are subservient. MIND is the functional power of the living brain. As I cannot conceive *life* any more than the power of attraction unless possessed by matter, so I cannot conceive *mind* unless possessed by a brain, or by some nervous organ, whatever name we may choose to give it, endowed with life. I speak of terrestrial or animal mind; with angelic and divine nature we have nothing to do, and of them we know, in the same respects, nothing. To call the human mind positively a ray of the divinity, (*Divinæ particula auræ* [u], *Ex ipso Deo decerptus, Ex universa mente delibatus* [x],) appears to me absolute nonsense. Brutes are as really endowed with mind, — with a consciousness of personality, with feelings, desires, and will, — as man.[y] Every child is conscious that it thinks with its head, and common language designates this part as the seat of mind.[z] Observation shows that superiority of mind in the animal creation is exactly commensurate with superiority of brain[a]; that activity of mind

[u] Horace.

[x] Cicero, *De Senectute et Quæst. Tuscul.*

[y] See Gall, l. c. t. 1. p. 56. sqq. Aristotle no sooner asserts that a share of divinity is bestowed on man " only of all animals," than he is obliged to retract, and say, " or most of all animals,"—ἢ μάλιστα παντων. *De part. animal.* l. ii. c. 10.

[z] A stupid person is honoured with the expressions numb-*scull*, thick-*head*, addle-*pated*, shallow-*pated*, badly furnished in the *upper story;* a clever person with strong-*headed*, long-*headed*, having plenty of *brains;* a madman is said to be wrong in the *head*, touched in the *noddle*, &c. A person whose memory or power of attention is impaired, says he has no *head*, &c. When a catarrh chiefly affects the head, we complain of stupidity, because " we have such a cold *in the head*," &c. A man is always said to have an idea in his *head*.

[a] " The same progression which exists in the gradual perfection of animal organisation, as far as regards vegetable life only, is observed in the gradual perfection of the nervous system, and of animal life which depends upon it. Comparative anatomy has followed the gradual perfection of animals, from the most simple absorbent vessels to the most complicated apparatus of mastication, deglutition, and digestion, — to the most perfect circulation. With every fresh viscus, every fresh apparatus for sensation, is discovered a fresh function, and this function is more complicated in proportion as the organisation of the viscus or apparatus of sensation is more perfect. The stomach, kidneys, lungs, heart, eyes, ears, are the more complicated as their functions become so.

" The same gradation may be demonstrated in the structure of the brains of the different species. I have demonstrated in the preceding chapter, that the existence of each moral quality and intellectual faculty, depends solely upon the

and of brain are coequal; and that, as long as the brain is endowed with life, and remains uninjured, it, like all other organs, can perform its functions, and mind continues; but, as in all

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presence of certain determinate cerebral parts, and not upon the whole mass of brain. It follows, that the number of the faculties is in direct proportion to the integrant parts of the brain. In insects, fish, and amphibia, the nervous mass contained in the cerebral reservoir, is still divided into several distinct masses. The greater part of these are not integrant parts of the brain, properly so called; they are ganglia, from which arise the nerves of smell, hearing, sight, &c. The two hemispheres, properly so called, are placed behind the two ganglia of the olfactory nerves, and are the more complicated as the industrial instincts are more numerous; the cerebellum in these animals generally forms a hollow pouch, sometimes placed horizontally, sometimes folded together.

" In birds, the two hemispheres are already more considerable, although distinct convolutions cannot be discerned. The cerebellum still consists merely of its middle or fundamental part; but already appears composed of many rings placed side by side.

" In the small mammalia, the shrew-mouse, mouse, rat, squirrel, weasel, &c. convolutions are not yet discoverable. But as they are already distinctly found in other larger rodentia, the beaver, kangaroo, &c., we may suppose that they equally exist in them.

" In the larger mammalia, the cat, polecat, marten, fox, dog, ape, the convolutions are more distinct and numerous, but their form varies according to the species.

" In the dolphin, elephant, and man, they are more numerous and deep than in the beaver, kangaroo, cat, &c., and their form and direction vary completely according to the species.

" In all the mammalia, the cerebellum possesses, besides the middle or fundamental part, two lateral parts, which are more or less complicated, according to the species; and as the *soi-disant* pons varolii, or the *soi-disant* cerebral ganglia, *i. e.* the transverse layers of nervous bands, are only the commissure or junction of the lateral parts of the cerebellum, they are found in all the mammalia, and in none of the ovipara.

" The number of the integral parts, or of the convolutions of the brain, varies equally in the different species of mammalia; in some, the anterior lobes of the hemispheres are larger or more elevated; in others, again, the inferior parts of the anterior lobes are nearly wanting. The middle lobes, and the other convolutions, present similar varieties.

" In this way, the integrant parts of the brain augment in number and developement, as we pass from a less perfec to a more perfect animal, till we arrive at the brain of man, who, in the anterior-superior, and in the superior region of the frontal bone, possesses several parts of which other animals are deprived, and by means of which he is endowed with the most eminent qualities and faculties, with reason, and the feeling of religion and the existence of God." Gall,

other organs, when its life ceases, its power to perform its function ceases, and the mind ceases: when disease or mechanical injury affects it, the mind is affected,—inflammation of the stomach causes vomiting, of the brain delirium, a blow upon the loins suppression or alteration of the urine, a blow upon the head stuns; if originally constituted defective, the mind is defective [c]; if fully de-

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l. c. t. ii. p. 364. sqq. "Some pretend to discover a striking resemblance between the brain of an orang-utan and that of man. But, in the first place, the difference of their volume is as five to one; their convolutions differ considerably in number and structure; the anterior lobes, especially, are contracted into a cone, flattened above, hollow below, &c.; and the difference is still more remarkable in other simiæ." t. vi. p. 298.

[c] See Gall, l. c. t. i. p. 196. sqq., and t. ii. p. 322. sqq. "Willis has described the brain of a young man imbecile from birth; its volume is scarcely $\frac{1}{5}$th part of that of an ordinary human brain. M. Bonn, professor at Amsterdam, has two little crania of idiots, and the brain of an imbecile who attained his twenty-fifth year, and was so stupid, that he was shown for money as an African savage," &c. "I have observed heads equally small in many living idiots from birth. All these crania and heads are 13 or 14 inches in circumference, and 11 or 12 inches from the root of the nose to the foramen occipitale."—"With from 14 to 17 inches in circumference; and about 10 or 12 from the root of the nose to the foramen occipitale, we have more or less stupidity, a more or less complete incapacity to fix the attention upon one object; uncertain and transitory feelings and passions; confusion of ideas," &c.—"Heads of 18 or 18½ inches in circumference are still small, although they permit a regular exercise of the faculties; they possess but a sad mediocrity of talent, a spirit of servile imitation, &c.; an extreme deficiency of seizing the relation between cause and effect; a want of self-government, and often few desires. Still some qualities or faculties may be considerable, because particular organs may be greatly developed, forming a striking contrast with the mediocrity of the rest. But as we approach larger brains, we see intellectual faculties of greater magnitude, till we arrive at heads 21 or 22 inches in circumference,—the dimensions at which men obtain the height of intelligence." Gall means French inches, which are about $\frac{1}{16}$ longer than the English.

"The dimensions of the brain," says Dr. Magendie, "are proportioned to those of the head. In this respect there is a great difference in individuals. The volume of the brain is generally in direct proportion to the capacity of the mind."—"It is rarely found that a man distinguished by his mental faculties has not a large head."—*Précis de Physiologie*, t. i. p. 184.

Dr. Marshall, an anatomical lecturer in London from two-and-forty to six-and-twenty years ago, taught that the brain was the organ of mind, its original defective conformation a source of idiocy, its disease the cause of insanity; and gave many dissections of maniacs, and an excellent sketch of the varieties of the disease. *Morbid Anatomy of the Brain, &c. collected from the papers of the late Andrew Marshall*, M.D., by S. Sawrey, London, 1815.

veloped, and properly acted on, the mind is vigorous: accordingly, as it varies with age, in quality and bulk, is the mind also varied,— the mind of the child is weak and very excitable, of the adult vigorous and firm, and of the old man weak and dull, exactly like the body[d]; and the character of the mind of an individual agrees

[d] If of children it is said,

—— "Inter se quas pro levibus noxiis iras gerunt?
Quapropter? quia enim qui eos gubernat animus, infirmum gerunt."
Terence, *Hecyra*.

The old man,—"Res omnes timide gelideque ministrat,
Dilator, spe longus, iners—" Horace, *Ars Poetica*.

Or, in the plainer language of Shakspeare, "Old men have grey beards, their faces are wrinkled, their eyes purging thick amber and plum-tree gum, and they have a *plentiful lack of wit*, together with most weak hams."
Hamlet, act 2. sc. 2.

Mr. Dugald Stewart allows that "In the case of old men, it is generally found that a decline of the faculties keeps pace with the decay of bodily health and vigour. The few exceptions that occur to the universality of this fact, only prove that there are some diseases fatal to life, which do not injure those parts of the body with which the intellectual operations are more immediately connected."—*Outlines of Moral Philosophy*, p. 233.

"Præterea gigni pariter cum corpore, et una
Crescere sentimus, pariterque senescere, mentem." Lucretius, lib. i.

"In new-born children, it is difficult to discern, without maceration in spirits of wine, any traces of fibres in the great collections of grey, reddish substances, or the great cerebral ganglia, which supply, reinforce, and perfect, or which, according to the opinion of others, give activity to, the hemispheres. The nervous fibres are more visible in the middle and posterior lobes than in the anterior. The fibrous structure of the white substance of the cerebellum also becomes apparent gradually, and in proportion to its developement. All the nervous fibres are at this period still so involved in the more or less reddish and gelatinous substance, and in blood-vessels, that all the brain looks like a nervous pulp or jelly.

"The only functions of the infant, at this age, are very imperfect, and are those of the five senses, of voluntary motion, hunger, the sensation of being comfortable or uncomfortable, and the want of sleep.

"After some months, the parts of the brain situated near the anterior-superior region of the forehead, grow more rapidly than the other parts. The forehead, from being flat, becomes prominent, and the child begins to fix its attention upon external objects, to compare, and form abstract ideas,—to generalise.

"The whole brain is developed in succession, until, at the age of from twenty to forty, it has attained its full growth relatively to each individual. The cerebellum, likewise, which is smaller than the cerebrum in proportion as the subject is

with the character of his body, being equally excitable, languid, or torpid, evidently because the brain is of the same character as the rest of the body to which it belongs, — the female mind exceeds the male in excitability as much as her body[e]; the qualities of the mind are also hereditary[f], which they could not be, unless they were, like our other qualities, corporeal conditions; and the mind is often disordered upon the disappearance of a bodily complaint, just as other organs, besides the brain, are affected under similar circumstances, — the retrocession of an eruption may affect the lungs, causing asthma; the bowels, causing enteritis; or the brain, causing insanity, — phthisis and insanity sometimes alter-

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younger, is developed and perfectly formed towards the age of from eighteen to twenty. The youth, the young man, and the young girl, take an interest in each other; and the talents and inclinations are exercised and perfected till they obtain maturity. From thirty or forty years of age, the cerebrum and cerebellum remain nearly stationary till the fiftieth or seventieth year, according to individual constitution. The same is the case with the moral and intellectual powers. Certain parts of the brain, however, especially those in the anterior-inferior region of the forehead, have at this time already begun to diminish; the memory is less faithful, and the imagination less ardent, and hint to us the approach of old age, and the decline of our faculties.

"At length all the cerebral mass gradually loses its nervous turgescence; it diminishes, wastes, shrinks ('the convolutions lie farther from each other;' t. i. p. 192.); the consistence of its two substances undergoes alteration. The moral and intellectual powers sink in proportion; the inclinations, the talents disappear, the affairs of the world assume a gloomy aspect, the past only is considered good; and, at the age of decrepitude, there remains only imbecility, the weakness of a second childhood." Gall, l. c. t. ii. p. 156. sqq.; also t. iii. p. 28. sqq. Dr. Magendie allows that "the brain is almost liquid in the fœtus, firmer in infancy, and still more so in manhood" (*Précis de Physiologie*); that above the age of seventy, the weight of the brain is on the average $\frac{1}{15}$th less than in the prime of life; and that the convolutions are then often distant half an inch from each other, and their surface very distant from the cranium, as Cotugno had observed. *Journ. de Physiol.* t. vii. p. 5. 87.

[e] "Mulieres sunt, ferme ut pueri, levi sententia." — Terence, *Hecyra*.

[f] "Parentibus liberi similes sunt non vultum modo et corporis formam, sed animi indolem, et virtutes, et vitia. — Claudia gens diu Romæ floruit impigra, ferox, superba: eadem illachrymabilem Tiberium, tristissimum tyrannum produxit: tandem in immanem Caligulam et Claudium, et Agrippinam, ipsumque demum Neronem, post sexcentos annos desitura." — Gregory, *Conspectus Medicinæ Theoreticæ*. So true is the verse

"Et patrum in natos abeunt, cum semine, mores."

nate with each other, just like affections of other organs; the laws of the mind are precisely those of the functions of all other organs,—a certain degree of excitement strengthens it; too much exhausts it; physical agents affect it, and some specifically, as is the case with other functions, for example, narcotics. The argument of Bishop Butler, that the soul is immortal and independent of matter, because in fatal diseases the mind often remains vigorous to the last [g], is perfectly groundless; for any function will remain vigorous to the last, if the organ which performs it is not the seat of the disease, nor much connected by sympathy, or in other modes, with the organ which is the seat of the disease—the stomach often calls regularly for food, and digests it vigorously, while the lungs are almost completely consumed by ulceration. All the cases that are adduced to prove the little dependence of the mind upon the brain, are adduced in opposition to the myriads of others that daily occur in the usual course of nature, and are evidently regarded as extraordinary by those who bring them forward. An exact parallel to each may be found in the affections of every other organ, and each admits of so easy an explanation, that it may be always truly said, "Exceptio probat regulam." [h]

[g] *The Analogy of Religion, natural and revealed, to the Constitution and Course of Nature.* By Joseph Butler, LL.D. Lord Bishop of Durham, p. 33.

[h] I will not insult the understanding of my readers by showing that we have no authentic instance of the real absence of brain in the cranium of a being possessed of a mind. The records of medicine no less teem with wonders than those of theology. The miracles of the Fathers and of the Romish Church may be matched by cases not only of mind without brain, or some similar organ, but of human impregnation without males, or by males without testes, and of human fœtuses nourished without communication with the mother.

In most cases where the mind is *said* to have been vigorous when the state of the body at large, or of the brain alone, rendered the perfect performance of the cerebral functions improbable in the eyes of the relaters, I believe the mental power has been greatly over-rated,—that, because the individual merely talked collectedly, he was imagined sufficient for the exertions of his best health.

The part of the brain affected by disease may have been one whose function is not intellectual, but merely relating to the feelings, or may have related to intellectual faculties whose state was not noticed by the narrators. In truth, the narrators give us no satisfactory account of the feelings and intellectual powers of the patients, nor of the exact portions of the brain affected; nor could they, being unacquainted with phrenology; and they also forget that the cerebral organs are all double. (See Gall, l. c. t. ii. 188. sqq., 246. sqq.; and a paper by Dr. Andrew

I have placed the preceding arguments alone, but to them may be subjoined another equally demonstrative as any, — that the stength of the various intellectual powers and inclinations accords with the size of the various parts of the brain; that exactly as the various parts of the brain are successively developed is the character developed, and as they shrink with age does the character again change.

In contending that the mind is a power of the living brain, and the exercise of it the functions of that organ, I contend for merely a physical fact; and no Christian who has just conceptions of the Author of Nature will hesitate to look boldly at Nature as she is, lest he should discover facts opposite to the pronunciations of his revelation; for the word and the works of the Almighty cannot

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Combe, on the effects of injuries of the brain upon the manifestation of the mind, in the *Transactions of the Phrenological Society*, Edinb. 1824.)

If after insanity no trace of disease is sometimes discoverable in the brain, let us remember that the same is sometimes the case after epilepsy and various undoubted diseases of the brain, and sometimes with respect to the stomach after chronic dyspepsia. Diseases may be functional only. Nay, when our senses are not nice enough to discover structural affection of the brain in insanity, &c. we have generally strong presumptive evidence of its affection, in the thickening or excessive secretions of its membranes,— points more easily ascertained than equal changes in the delicate texture of the brain.

Those who thus attempt to prove the *substantial distinctness* of the mind and brain, forget that their facts, or rather arguments, are equally strong against what they all admit, — the necessary *connection* of the mind and brain in this life; and are therefore grounded on what, if true, were violations of the course of nature.

There is a passage in Hippocrates, *de Morbo Sacro*, well worth quoting: — " Men ought to know, that from the *brain only* proceed pleasure and joy, and laughter and sport, as well as griefs, anxieties, sorrows, and weeping. By it we are wise especially, and understand, and see, and hear, and appreciate what is base and honourable, good and bad, pleasant and unpleasant, distinguishing them partly by habit, partly by their utility. By it we distinguish what is pleasurable, and what disagreeable, according to circumstances; and, by it, the same things do not please us under all circumstances. By it we are insane and delirious; experience terrors and fears, partly by night, partly by day; and sleeplessness, and ill-timed errors, and groundless cares; do not recognise those who are with us; lose our habits, and forget our experience. And all this we suffer from the brain if it is not healthy, &c.: wherefore I say, that the brain is the messenger and interpreter of intelligence and wisdom. But the *præcordia* have obtained the name of φρένες among the Greeks, by custom, not from fact and nature; and I know not what property they have of knowing and understanding, except that in sudden and great joy or sorrow they leap," &c.

contradict each other. Bacon accordingly, in a very memorable part of his writings, directs the physical enquirer to be uninfluenced by religious opinions[i], as the more independently truth is pursued the sooner will it be gained, and the sooner will the real meaning of a divine statement of natural things, and the conformity of this to physical fact, be established.

The assertion, however, that the mind is a power of the living brain, is not an assertion that is material; for a power or property of matter cannot be matter.

Neither is it an assertion that this power cannot be a something immortal, subtle, immaterial, diffused through and connected with the brain. A physical enquirer has to do with only what he observes. He finds this power, but attempts not to explain it. He simply says the living brain has this power, medullary matter though it be. Seeing that the brain thinks, and feels, and wills, as clearly as that the liver has the power of producing bile, and does produce it, and a salt the power of assuming a certain form, and does crystallise, he leaves others at liberty to fancy an hypothesis of its power being a subtle, immaterial, immortal substance, exactly as they fancy life to be a subtle fluid, or, perhaps, though very extraordinarily, the same subtle fluid (if subtlety is immateriality and immortality)[k], elucidating the subject

[i] Si quis animum diligentius advertat, non minus periculi naturali philosophiæ ex istiusmodi fallaci in iniquo fœdere, quam ex apertis inimicitiis imminere. Tali enim fœdere et societate accepta, in philosophia tantum comprehendi, aucta autem, vel audita, vel in melius mutata, etiam severius et pertinacius excludi. Denique versus incrementa et novas veluti oras et regiones philosophiæ, omnia ex parte religionis, pravarum suspicionum et impotentis fastidii plena esse. Alios siquidem simplicius subvereri, ne forte altior in naturam inquisitio ultra datum et concessum sobrietatis terminum penetret, &c. &c. Quare satis constabat in hujusmodi opinionibus multum infirmitatis, quin et invidiæ et fermenti non parum subesse," &c. — *Cogitata et Visa*, vol. ix. p. 167. 8vo edition. In the same paragraph he remarks, with regret, that no writers are more popular than those who pompously set forth the union of divinity and philosophy, *i. e.* faith and sense, as if it were not illegitimate. " Haud alias opiniones et disputationes magis secundis ventis ferri reperies, quam eorum, qui, theologiæ et philosophiæ conjugium, veluti legitimum, multa pompa et solemnitate celebrant, et grata rerum varietate animos hominum permulcentes, interim divina et humana inauspicato permiscent."

[k] The hypothesis of a subtle mobile fluid is downright materialism — the doctrine of Lucretius.

—— " Quoniam est animi natura reperta
Mobilis egregie, perquam constare necesse est
Corporibus parvis et lævibus atque *rotundis*." Lib. iii. 204.

no more than in the case of life, and equally increasing the number of its difficulties [1]; as though we were not *created* beings,

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Bacon complained (l. c.) that the first attempts to explain thunder and tempests were accused of impiety by religious persons, who thought that religion demanded these phænomena to be referred to the immediate operation of the Deity. The lovers of subtle fluids and spirits, conversely and as strangely, think religion served by interposing a subtle fluid between common matter and the Deity. Van Helmont was remarkably fortunate, for, after severe meditation, he fell into an intellectual vision, and saw his own soul: " Magna mox quies me invasit, et incidi in somnium intellectuale satisque memorabile." It was very small, and had no organs of generation: " Vidi enim animam meam satis exiguam, specie humana, sexûs tamen discrimine liberam."—*Ortus Medicinæ,* Confessio auctoris, p. 13. He gave the soul, however, a close and dirty dwelling, for he placed it, not in the pineal gland, but in the stomach.

[1] Locke (*Second Reply to the Bishop of Worcester*, p. 477. 8vo edition) in disparaging *philosophical* reasons for the immortality of the soul, says,

" Dr. Cudworth affirms that there was never any of the ancients before Christianity that held the soul's future permanency after death (*i. e.* from its inherent immortality), who did not likewise assert its pre-existence." If we *necessarily* shall exist *to* all eternity, we then must have existed *from* all eternity; yet we are not aware of having been alive before our brains. Sterne's fine ridicule of the absurdities introduced by this hypothesis of a soul, and that independent of the brain, into the Romish church, is well known. A great French man-midwife acquaints us that he baptised a little abortion of the magnitude of a skinned mouse; and on another occasion, when a woman was miscarrying in her fourth month, and the child's posteriors presented, that he sprinkled water upon them and baptized them, in case the little thing should turn out alive. (De la Motte, *Traité complet des Accouchemens,* p. 243. 246.) Dr. Fodéré in his noted *Médecine Légale,* 1813, (vol. ii. p. 62.) gravely suggests that baptism may always be administered by a squirt, after the membranes are pierced, — " Quant au baptême, il me semble qu'il sera toujours facile de l'administrer, après avoir percé les membranes, par le moyen d'un seringue à injection." A good idea of what follows in its train may be collected from Dante's tiresome account of the introduction of the soul into the body, beginning, " Sangue perfetto che mai non si beve," &c. — *Purgatorio,* canto xxv. It is one parent of necromancy, of the belief in ghosts, and of all the popish " trumpery " respecting purgatory and the worship of dead people called saints, of the opinions held by many respecting our occupations between death and doomsday, as if a future state began before; and old writers sicken one with their notions about the period at which the soul enters the body, when it first existed, how it was engaged before it united with the body, and how it employs itself after its separation till the day of judgment, &c. " Hierom, Austin, and other fathers of the church, hold that the soul is immortal, created of nothing, and so infused into the child or embryo in his mother's womb six months after the conception; some say at three days, some six weeks, others otherwise."—Burton's *Anatomy of Melancholy,* p. 1. s. 1. m. 2 subs. 9. Where

or not altogether ignorant what matter is, or of what it is capable and incapable; as though matter exhibited nothing but extension, impenetrability, attraction, and inertness; and as though an Almighty could not, if it seemed good to him, have endowed it, as he most evidently has, with the superaddition of life, and even of feeling and will.[m]

Nor does this assertion imply that the resurrection from the dead is impossible, or even improbable. The physical enquirer, finding the mind a power of the brain, and abstaining from hypothesis, must conclude that, in the present order of things, when the brain ceases to live the power necessarily ceases, — that, in the language of scripture, Dust we are, and unto dust we all return, — that our being is utterly extinguished, and we go back to the insensibility of the earth whence we were taken.[n] Our

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the depôt of souls is; how they learn when a youth has impregnated an ovarian vesicle, and how they fly to and get into it; how it happens that the qualities of the soul correspond with the brain, and are as hereditary as those of the body; whether this depends upon souls varying, and, if so, how a soul finds a body just corresponding to itself; or upon the soul being obliged to conform to the character of the brain, and thus suffering by the brain's defects, we are not satisfactorily informed.

[m] "All the difficulties that are raised against the thinking of matter, from our ignorance or narrow conceptions, stand not at all in the way of the power of God, if he pleases to ordain it so." The faculties of brutes prove, "either that God can and doth give to some parcels of matter a power of perception and thinking, or that all animals have immaterial and consequently immortal souls as well as men; and to say that fleas and mites, &c. have immortal souls as well as men, will possibly be looked on as going a great way to serve an hypothesis."—Locke, *Second Reply to the Bishop of Worcester*, p. 466. 8vo edit.

"Si quelqu'un démontreroit jamais que l'âme est matérielle," says the pious and benevolent Bonnet, "loin de s'en alarmer, il faudroit admirer la puissance qui auroit donné à la matière la capacité de penser."

"In the ordinary derivation of plants and animals," says Paley, "from one another, a *particle*, in many cases minuter than all assignable, all conceivable dimensions; an aura, an effluvium, an infinitesimal; determines the organisation of a future body: does no less than fix, whether that which is about to be produced shall be a vegetable, a merely sentient, or a RATIONAL *being*; an oak, a frog, or a *philosopher*; makes all these differences; gives to the future body its qualities, and nature, and species. And this *particle*, from which *springs*, and by which is determined, a whole future nature, itself *proceeds* from, and owes its constitution to, a prior body," &c. — *Natural Theology*, conclusion, p. 591.

[n] *Miscellaneous Tracts, &c.* by Richard Watson, D.D. F.R.S. Lord Bishop of Llandaff. Sermon iii. p. 399. sq.

consciousness of personality can afford no reason for imagining ourselves immortal and distinct from earth, more than brutes; for this the fly possesses equally with the philosopher about whose head it buzzes.[o] The moral government of the world, the sublime reach of our acuteness, the great improveableness of our characters, —

> " —— this pleasing hope, this fond desire,
> This longing after immortality,
> —— this secret dread and inward horror
> Of falling into nought,"[p]

have been thought to completely harmonise with a life hereafter, but certainly fall so short of proof as to have left the wisest of antiquity,—Solomon, Socrates, Cicero, &c.—in uncertainty[q], when they saw how death reduces us to our pristine elements. The hope of immortality inspired by such reflections, assisted by the desire of explaining every thing in some way or other, first, I apprehend, made men attempt to find, in the imagined ethereal essence of the soul, a reason for our not totally perishing as our senses would lead us to suppose. But, because we refuse to listen to a mere hypothesis respecting spirit, we are not *necessarily* to deny the resurrection. For if a divine revelation pronounce that there shall be *another order of things* in which the mind shall exist again, we ought firmly to believe it, because neither our experience nor our reason can inform us what will be hereafter, and we must be senseless to start objections on a point beyond the penetration of our faculties.[r]—The scripture so pronounces,

[o] Heathens have, very consistently with this reason for immortality, given it to the fancied souls of brutes: Ulysses is made by Homer to behold the shade of Orion —

> Θῆρας ὁμῦ εἰλεῦντα, κατ' ἀσφοδελὸν λειμῶνα
> Τοὺς αὐτὸς κατέπεφνεν ἐν οἰοπόλοισιν ὄρεσσι. Odyss. Λ. 571.

Dr. Thomas Brown believed, " that the *metaphysical* ARGUMENT which proves the immortality of man, extends with equal force to the other orders of earthly existence." *Memoir of Thomas Brown*, M.D., by the Rev. David Welsh. 1828, p. xxii.

And " Bonnet promised brutes immortality."

[p] Addison, *Cato*. See a full enumeration in Mr. Dugald Stewart's *Outlines*, &c. p. 235. sq.

[q] Bishop Watson, l. c. Sermon vi. p. 504. sq.

[r] " Nor can we be obliged, where we have the clear and evident sentence of reason, to quit it for the contrary opinion, under a pretence that it is a matter of faith, which can have no authority against the plain dictates of reason. But

—not that we are naturally immortal, but that "in Adam (by nature) all die[s], —have our being utterly extinguished[t], and in another order of things,—when the fashion of this world shall have passed away and time shall be no more, that in Christ (by the free, additional, gift of God, granted through the obedience of Christ, but, consequently, *by a miracle*, not by our nature[u])—we shall all again be made alive. St. Paul declares the resurrec-

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there are many things wherein we have very imperfect notions, or none at all; and other things, of whose past, present, or future existence, by the actual use of our faculties, *we can have no knowledge*: these, as being beyond the discovery of our natural faculties, and above reason, are, when revealed, the proper matter of faith. Thus, that part of the angels rebelled against God, and thereby lost their first happy state, and that *the dead shall rise and live again*: these and the like, being beyond the discovery of reason, are purely matters of faith, with which *reason has nothing directly to do*." — Locke, *Essay on Human Understanding*, iv. ch. 18.

Reason's province is only to examine the proofs of the authenticity of a revelation, and faith should thus be founded on reason. But how few of the human race ever think, or are even capable, of carefully examining them! And of those who do examine them, how few do not commence the examination with their minds unconsciously half made up! And yet the greater number look down with a self-complacent and uncharitable feeling upon even good men, whose opinions differ in any respect from their own; forgetting that good conduct is the only test of goodness, — that grapes cannot come from thorns, nor figs from thistles.

The question of the authenticity of Scripture is altogether foreign to this work.

[s] Bishop Watson, *Apology for the Bible*, Letter x. near the end.

[t] Idem, *Miscellan. Tracts*, l. c. — Dr. Law, Bishop of Carlisle, in his *Theory of Religion*, &c., which went through seven editions, asserts that the sentence of death passed upon Adam and Eve meant nothing less than a *total destruction of existence*; and that the idea of its implying a continuation of consciousness and real existence in some other place than earth, is not sanctioned by Scripture, but is the *philosophy of after-ages*. — p. 345. He adds, that Bishop Tillotson, though a patron of this notion, confesses it is not found in the Bible: and, after a critical and elaborate examination of the words used in Scripture to denote *soul* and *spirit*, and their various applications, he sums up the enquiry thus: — "But neither do *these words*, nor any other, so far as I can find, *ever* stand for a *purely immaterial principle* in man, or a substance, whatever some imagine they mean by that word, wholly separable from, and independent of, the body."

Bishop Sherlock employs strong expressions: — "Scholars may reason on the nature of the soul, and the condition of it when separated from the body: but the common hopes of nature receive no support from such enquiries. We die and moulder to dust; and in that state, what we are, or where we are, nature cannot say." *Discourse* ii. p. 85. and vol. iv. p. 79.

[u] Bishop Watson, *Apology*, l. c.

tion to be "*a mystery*:" it must, in truth, be a *miracle*; and therefore the enquiry, "how can these things be," altogether fruitless. The miracle of Christ's resurrection, to which the Scriptures refer us as the foundation of the hope of a future state, would not have been necessary to convince us of a necessary truth, discoverable by sense and reason. That the promises of the New Testament are the proper and *only* foundation of our hopes of immortality, was the opinion of the late Regius Professor of Divinity in the University of Cambridge, whose powerful intellect and sincere love of truth render his opinions weightier than the decrees of councils. "I have no hope of a future existence," says he, "except that which is grounded on the truth of Christianity."[x]

[x] *Anecdotes of the Life of* Richard Watson, D.D. F.R.S. late Lord Bishop of Llandaff. — Vol. i. p. 107. See also a very decisive passage, beginning — "As a Deist, I have little expectation; as a Christian I have no doubt, of a future state," in his *Apology for the Bible*, Letter x. near the end.

Bishop Jeremy Taylor, in his *Doctrine of Original Sin*, p. 24., assures us that the words — "Since by man came death, by man came also the resurrection from the dead," and, "as in Adam all die, even so in Christ shall all be made alive," directly affirm that a resurrection, or being *made alive again*, is granted, assured, and executed by and in Christ alone; and evidently suppose that the dead are not made alive till the resurrection, and that, had not a resurrection been provided, we should never, after death, have been made alive.

Locke argues, "that all the great ends of religion and morality are secured barely by the immortality of the soul, without a necessary supposition that it is immaterial." — *First Reply*, p. 34.

Mr. Dugald Stewart concedes that "the proper use of the doctrine of the immateriality of the soul is not to demonstrate that the soul is physically and necessarily immortal." l. c. p. 227.

Dr. Rush, of America, remarks upon this subject, "that the writers in favour of the immortality of the soul have done that truth great injury by connecting it necessarily with its immateriality. The immortality of the soul depends upon the will of the Deity, and not upon the supposed properties of spirit. Matter is in its own nature as immortal as spirit. It is resolvable by heat and moisture into a variety of forms; but it requires the same almighty hand to annihilate it, that it did to create it. I know of no arguments to prove the immortality of the soul but such as we derive from the Christian revelation." — *Medical Inquiries and Observations*, vol. ii. p. 15.

"I rather think," says Dr. Priestley, "that the whole of man is of some uniform composition, and that the property of perception, as well as the other powers that are termed mental, is the result (whether necessary or not) of such an organised structure as the brain. Consequently, that the whole man becomes extinct at death, and that we have no hope of surviving the grave, but what is derived from the scheme of revelation." — *First Introductory Essay to his Edition of Hartley*, p. xxiii. sq.

While those are wrong who think there can be any thing like an argument against a future life in another order of things, if declared by a revelation, it is strange that others should think it necessary to attempt rendering the pronunciations of scripture more probable, and that by an hypothesis which is at best but the remains of unenlightened times [y], and should require any as-

[y] The more uninformed the age, the greater the disposition to explain every thing. The savage personifies the winds and the heavenly bodies; the ancients fancied all matter endowed with a spirit — *spiritus intus alit.* Philo and Origen maintain that the stars are so many souls, incorruptible and immortal. In the older writings of the moderns, even in those of the father of experiment and observation — Lord Bacon, the properties of matter are referred to spirits: — " from them and their motions principally proceed rarefaction, colliquation, concoction, maturation, putrefaction, vivification, and most of the effects of nature;" " for tangible parts in bodies are stupid things, and the spirits do, in effect, all." (*Natural History,* cent. i. 98.) — In fact, some authors believe in three souls — the vegetable, sensible, and natural — for vegetables, brutes, and man; those which have the second having also the first, and those who have the third having all three. Paracelsus believed in four. These old writers, in providing a spirit for every thing, were more consistent than the moderns, who require it for only life and mind; because a subtle fluid or spirit is quite as necessary to explain the arrangement of saline particles into the regular form of a beautiful crystal. All these notions still exist among the vulgar; and the last remaining among the better informed, though it too is rapidly dying away, relates to mind. Those who upbraid others for refusing their assent to this hypothesis, may recollect that Anaxagoras and many more were accused of atheism and impiety, because they denied that the heavenly bodies were animated and intelligent. Even in the last reign but one, the Newtonian doctrines were thought irreligious by the Hutchinsonian sect, to which Bishop Horne, the amiable writer on the Psalms, and Mr. Jones, the learned and ingenious writer in defence of the Trinity, belonged: and the Jesuits, in their edition of Newton, 1742, carefully disclaim all belief in his demonstration of the earth's motion, as this is decreed false by the Pope.

Materialist is as good a word as any other for branding those from whom we differ; but materialism in its true acceptation signifies the doctrine of no first cause, or that all has been produced *ex fortuita atomorum collisione.* The whole tenor of scripture implies that *we* are *bodies* endowed with certain properties; and those passages from which our having a distinct immaterial substance is inferred, may be easily explained by the figurative style of the Bible, by the necessary adoption of the language of the times, and by the influence of the national opinions and prejudices of the writers on their modes of expression. Without due allowance, we might deem it impious to deny that " the round world cannot be moved;" that the sun " pursues its course" round the earth; (Galileo was imprisoned for doing so, and yet, said the sage to himself while in prison, " the earth does move" — *e pur si muove:*) that Naaman's leprosy (a condition of body) was a real substance, because we read that it left him and

surance besides that of the gospel, which, they read, "has

"clave unto Gehazi;" that Adam "surely" (more properly "utterly," "totally," or "entirely") died on the very day he tasted the forbidden fruit; that the winds possessed sense, because Christ said, "Peace, be still;" that the earth is square, because we twice read of its four corners (*Isa.* xi. *Rev.* vii.); and that Saul's melancholy, and the cases of insanity and epilepsy related in the New Testament, were possessions by demons, which are pronounced by St. Paul to be "nothing in the world." (See the Rev. Hugh Farmer's original and admirable works, especially his *Essays on the Demoniacs of the New Testament*, and *on Christ's Temptation.*) Without due allowance, what absurdities might not be inferred from Christ's use of the word heart? But the most enlightened divines allow us at present to follow Bacon's advice, and to read the Bible, not as a work of philosophical instruction, but of the revelation of religious matters beyond our knowledge, *v. c.* to learn from Genesis only how the world was created by God, and to study geology without reference to Moses. "The expressions of Moses are evidently accommodated to the first and familiar notions derived from the sensible appearances of the earth and heavens; and the absurdity of supposing that the literal interpretation of terms in Scripture ought to interfere with the advancement of philosophical enquiry, would have been as generally forgotten as renounced, if the oppressors of Galileo had not found a place in history." *A Treatise on the Records of the Creation*, &c., by J. B. Sumner, M. A., Prebendary of Durham, &c. now Bishop of Chester, 3d edit. 1825, vol. i. p. 327. We may, therefore, learn the miracle of the resurrection from the gospels, and enjoy our own opinions respecting matter and spirit, body and soul, which, as relating to our nature, are objects of physical enquiry, and therefore not of revelation, any more than astronomy or geology. The writer of the celebrated *Apology for the Bible* says, "when I went to the University, I was of opinion, as most schoolboys are, that the soul was a substance distinct from the body, and that when a man died, he, in classical phrase, breathed out his soul, *animam expiravit;* that it then went I knew not whither, as it had come into the body, from I knew not where nor when, and had dwelt in the body during life, but in what part of the body it had dwelt I knew not."—"This notion of the soul was, without doubt, the offspring of prejudice and ignorance."—"Believing as I do in the truth of the Christian religion, which teaches that men are accountable for their actions, I trouble not myself with dark disquisitions concerning necessity and liberty, matter and spirit; hoping as I do for eternal life through Jesus Christ, I am not disturbed at my inability clearly to convince myself that the soul is or is not a substance distinct from the body." —*Anecdotes of the Life of Bishop Watson*, p. 14. sqq.

"Well indeed is it for us," says a liberal writer in the *Quarterly Review*, on the subject of geology, "that the cause of revelation does not depend upon questions such as these; for it is remarkable that in every instance the controversy has ended in a gradual surrender of those very points which were at one time represented as involving the vital interests of religion. Truth, it is certain, cannot be opposed to truth. How inconsiderate a risk, then, do those advocates run, who declare that the whole cause is at issue in a single dispute, and that the sub-

brought life and immortality to light.[z] They should reflect that the belief of an immaterial substance removes no imagined difficulty, as it is the peculiar doctrine of scripture, in distinction to that of most heathen philosophers and people[a], that the resurrection will be positively of *body*, — that in our *flesh* we shall see God[b], and that therefore our minds, according to the scripture doctrine, must appear as much a property of body hereafter as at present.[c]

Only this — the Christian — account of a future state is reason-

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stance of our faith hangs upon a thread — upon the literal interpretation of some word or phrase, against which fresh arguments are springing up from day to day!" 1823, April, p. 163.

The Theory of Religion, by the learned, able, and enlightened Bishop Law, already quoted, deserves to be read by every one, as proving that by the words *soul* and *spirit*, no immaterial, immortal principle in man is meant, but merely person, the superior and inferior mental faculties, living creature, &c.; by *death*, a total cessation of existence; by *the life hereafter*, a second *bodily* existence. It is to this admirable divine that Paley dedicates his *Principles of Moral and Political Philosophy*, and says — " Your Lordship's researches have never lost sight of one purpose, namely, to recover the simplicity of the Gospel from beneath that load of *unauthorised* additions, which the *ignorance* of some, and the *learning* of others; the *superstition* of weak, and the *craft* of designing men, have (unhappily for its interest) heaped upon it. And this purpose, I am convinced, was dictated by the purest motive; by a firm, and, I think, a just opinion, " that whatever renders religion more rational, renders it more credible: that he who, by a diligent and faithful examination of the original records, *dismisses* from the system one article which *contradicts* the apprehension, the experience, or the reasoning of mankind, does more towards recommending the belief, and, with the belief, the influence of Christianity, to the understandings and consciences of serious enquirers, and through them to universal reception and authority, than can be effected by a thousand contenders for creeds and ordinances of human establishment."

For an account of all the hypotheses that have been taught upon life and mind, see *An Enquiry into the Opinions, ancient and modern, concerning Life and Organisation*. By John Barclay, M.D., Edinb. 1822.

[z] 2 Timothy, i. 10.

[a] " Errant exsangues sine corpore et ossibus umbræ."—Ovid. *Metam.* iv.

[b] *Job.*

[c] It is the doctrine of the Church of England, that all men *shall rise with their bodies*. Enoch and Elijah are represented to have been translated *bodily*. Nay, our church has so little of this horror of matter, that it declares that Christ, " the very and eternal God" (Article ii.), ascended into heaven, and there sits, with " his body, with *flesh, bones,* and all things appertaining to the perfection of man's nature." Article iv.

able. The heathen doctrine was grounded on the supposed inherent immortality of a supposed substance distinct from the body. The Christian doctrine teaches the resurrection of what we obviously are — *bodies*, and that through a *miracle* of the Almighty.[d]

[d] Respecting a difficulty which may present itself to the conceptions of some Christians, but which the *miraculousness* of a future existence, I think, should remove, I may quote Paley's sermon on the state after death. He concludes,

"That it is a question by which we need not be at all disturbed, whether the bodies with which we shall arise be new bodies, or the same bodies under a new form:

"For no alteration will hinder us from remaining the same, provided we are sensible, and conscious that we are so; any more than the changes which our visible person undergoes even in this life, and which from infancy to manhood are undoubtedly very great, hinder us from being the same, to ourselves and in ourselves, and to all intents and purposes whatsoever." — *Sermons on several Subjects*, by the late Rev. W. Paley, D.D. serm. 3. p. 96. These are a small system of divinity, and, having been bequeathed by him to his parishioners, probably contain his mature convictions.

II. SPECIAL PHYSIOLOGY.

CHAP. I.

HUNGER, THIRST, AND FOOD.

THE solid and fluid substances, taken into the mouth to repair the losses of the system, are termed *food* and *drink;* or both are comprised under the word *food.*

The desire for the former is called *hunger* or *appetite,* and for the latter, *thirst.*

" Some ascribe *hunger* to an uneasiness arising in the stomach from its being empty and unoccupied; others, to the mutual friction of its rugæ; others, not only to the stimulus of its fluids, now secreted in abundance, — of the saliva and gastric juice, but to an acrimony which they acquire when food is not taken in proper time."

If hunger arise from merely a sense of vacuity in the stomach, why should it be increased by the application of cold to the surface, and instantly by the deglutition of cold liquids, &c.?

The explanation by friction of the rugæ is equally unsatisfactory; because the friction of these, if it does really occur, cannot be greater than the friction of the stomach against its contents immediately after a meal, when the organ is in great action, but at which time hunger does not exist.

Nor can the presence of the gastric juice explain the matter: because, as every one knows, no sensation arises in any other organ, which is not excrementory, from the peculiar stimulus of its natural fluid, and I presume that this is the stimulus intended, for the mechanical stimulus, from the bulk of the gastric juice, occurs equally from the presence of food, which does not excite hunger; because, if the hungry stomach is evacuated by vomiting, as in sea-sickness, the appetite, when the sickness has ceased, is even greater than before; and because hunger often ceases after a time, though the gastric juice still remains in the stomach, and is probably more abundant than ever.

The supposition of an acrimony generated in the gastric juice, &c. being a cause of hunger, is absurd. The fluid would be unfit for its purposes, and would be more likely to destroy than produce appetite.

Hunger has been attributed by some to a sympathy of the stomach with a general feeling of want in the system. But hunger is removed *immediately* that a due quantity of food is swallowed,—long before the general system can have derived benefit from the meal: fowls are satisfied when their crops are filled, although their food is not even ground, *preparatorily* to digestion, till it has passed from the crop into the gizzard; and ruminating animals leave off eating before they begin to chew the substances with which they have distended their stomachs. Again, persons unable to obtain food in sufficient quantity lessen their hunger by swallowing any innutritious and indigestible matter. The circumstance giving rise to this opinion is the continuance of hunger although food be taken in abundance, in cases of scirrhous pylorus and enlarged mesenteric glands. Here, it is urged, the hunger continues, because the body receives no nourishment. But, in scirrhus of the pylorus, vomiting generally soon follows the reception of food into the stomach; and therefore this organ is reduced to the condition in which it was previously, and the return of hunger is easily explicable: but I do not know that a continued hunger commonly occurs in cases of scirrhous pylorus. In diseases of the mesenteric glands there is, in fact, no obstruction to the course of the chyle. They are found permeable, according to Dr. Boekker, a German anatomist, and the continued hunger appears rather a part of the diseased state of the chylopoietic viscera. Besides, many cases of imperfect nutrition, from various causes, occur, without any increase of appetite:—and where there is an increase of appetite, the process of digestion seems to proceed with unusual rapidity, so that the stomach becomes empty sooner than in health.—In continued abstinence, although the system is daily more in want, hunger usually ceases after a few days, whether from the stomach falling into a state of relaxation, becoming distended with wind, or from other circumstances.

If hunger arose from fatigue of the stomach, it should be greatest immediately after the laborious act of digestion, and gradually decrease; but it on the contrary increases.

Were irritation the cause, hunger should be greatest when the stomach is filled with food.

On the whole, hunger may perhaps be regarded as a sensation connected with the contracted state of the stomach.

It occurs when the stomach, being empty, must be contracted, and is increased *instantaneously* by a draught of cold liquid, which cannot but contract the stomach, and corrugate its inner coat: acids, bitters, and astringents have the same effect, and from their nature they may be supposed to act in the same way. Cold air applied to the surface increases it, and, in all probability, by a similar operation; for the impression of cold upon the skin excites an attempt at evacuation in the urinary bladder, and, when all other means fail to induce the intestines to expel their contents or the uterus to contract after delivery, the affusion of cold water so frequently succeeds, that the omission of the practice in obstinate cases is highly censurable. It is diminished by heat and every thing which relaxes. Again, it ceases immediately that the stomach is filled and thus the organ dilated and all corrugation removed; and, the more the contents of the stomach are of a nature to be absorbed or passed into the duodenum, the sooner it recurs. Distension of the stomach is universally acknowledged to be incompatible with hunger; whence the proverb, — " a *full* belly loathes the honey-comb."

The Otomacs during the periodical inundation of the rivers of South America, when the depth of the waters almost entirely prevents fishing, appease their hunger for two or three months by distending their stomach with prodigious quantities, a pound a day and upwards, of a fine unctuous, strong-smelling, yellowish-grey clay, slightly baked, and destitute of all organic substance, oily or farinaceous.[a] The savages of New Caledonia, in the Pacific Ocean, in times of scarcity, do the same by eating a friable lapis ollaris, consisting of equal parts of magnesia and silex, with a little oxide of copper. The wolves, rein-deer, and kids of Siberia, when pressed by hunger in winter, also devour clay or friable steatites. The Kamtschatkans sometimes appease their hunger by distending their stomach with sawdust, for want of something better.

Being, in this view, a sensation connected with a local state of the stomach, it will be affected not only by whatever affects this state, but by whatever affects also the sensibility to this state, and

[a] Humboldt, *Tableaux de la Nature,* t. i. They become so fond of it, that they take a little, even when well provided with sustenance, and are compelled to tie their children's hands to prevent them from *geophagising.*

therefore be subject to the common laws of sensation. Hence uncivilised tribes enable themselves to traverse large tracts without food by swallowing pills containing tobacco or opium. The pain of all excessive muscular contraction is lessened by pressure; whence the uneasiness of hunger is lessened by a belt fixed tightly over the stomach; and some Northern Asiatic tribes really place a band there, and lace it behind with cords drawn more tightly, according to the degree of the uneasiness. Thus, too, the state of the stomach remaining the same, hunger may diminish from the occurrence of other feelings which attract our attention more forcibly, by passions of the mind, &c.: as is exactly the case with all other sensations, even with those that are morbid. Under strong attention of the mind to pursuits of either intellect or passion, to delightful or painful sensation, all other feelings cease to be felt, although really violent; and frequently, from being unattended to, do not recur. Passions, however, and the narcotic pills of savages, may affect hunger, not only by increasing or diminishing the sensibility to the state of the stomach, but by increasing or diminishing this state — the cause of the sensation.

As hunger appears to depend upon the local condition of the stomach, so does *thirst* more evidently upon that of the mouth and fauces. Every consideration renders it probable that thirst is the sensation of the deficiency of moisture in the parts in which it is seated. Whatever produces this, either by causing the fluids of the mouth and fauces to be secreted in small quantity or of great viscidity, or by carrying off the fluid when secreted, produces thirst; and vice versâ. *To be dry* means to be thirsty, because the state is removed by directly wetting the parts, or by supplying the system with fluid, that they may be moistened by their own secretions. Being a sensation, the same may be repeated in regard to it as was observed respecting hunger. Rage or terror dry up the mouth and throat, and cause violent thirst. Thirst is only momentarily assuaged by wetting the mouth and throat, because they presently grow dry again. Fluids must be swallowed to be effectual, that they may be absorbed and the part thus preserved moist by constant secretion.

" The necessity of obeying those stimuli is greater or less, according to age, constitution, and especially according to habit, and nothing can therefore be affirmed positively respecting its urgency; but a healthy adult, in whom all the calls of nature are

felt in their usual force[b], cannot abstain from food a whole day without great prostration of strength, nor scarcely beyond eight days without danger to life."

Hippocrates says that most of those who abstain from food for seven days, die within that period; and, if they do not, and are even prevailed upon to eat and drink, that still they perish.[c] Sir William Hamilton, however, saw a girl, sixteen years of age, apparently not in bad health, who was extricated from the ruins of a house at Oppido, in which she had remained eleven days without food: an infant in her arms, but a few months old, had died on the fourth day, as the young are never so able to endure abstinence.[d] A moderate supply of water lengthens life astonishingly. Dr. Willan was called to a young gentleman who had voluntarily abstained from every thing but a little water, just flavoured with orange *juice*, for sixty days: death ensued a fortnight afterwards.[e] Redi cruelly found that of a number of starved fowls deprived of water, none lived beyond the ninth day, whereas one indulged with water lived upwards of twenty.[f] If the water is not swallowed, but imbibed by the surface or lungs, it may also prolong life. Fodéré mentions some workmen who were extricated alive at the end of fourteen days from a cold damp cavern in which they had been buried under a ruin.[g]

In abstinence equally great imbecility of mind takes place as of body: extreme emaciation and œdema of the legs present a frightful spectacle; urine may still be secreted, but the alvine discharge is greatly diminished, or suppressed altogether; the pain

[b] "Consult, among innumerable writers on long fasting, James Barthol. Beccarius, *Commentar. Instituti Bononiens.* t. ii. p. 1.; and Flor. J. Voltelen, *Memorab. Apositiæ Septennis Hist.* Lug. Bat. 1777, 8vo."

[c] *De Carnibus.*

[d] *Phil. Trans.* vol. lxxiii. p. 191. sq.

[e] *Medical Communications,* vol. ii.

[f] *Osservaz. intorno agli anim. viventi.*

[g] Fodéré, *Médecine Légale,* t. ii. p. 285. A hog, weighing about 160 lbs., was buried in its sty, under thirty feet of the chalk of Dover Cliff, for 160 days. When dug out it weighed but 40lbs., and was extremely emaciated, clean, and white. There was neither food nor water in the sty when the chalk fell. It had nibbled the wood of the sty, and eaten some loose chalk, which from the appearance of the excrement had passed more than once through the body. (*Linnæan Transact.* vol. xi. See *London Med. Journ.* vol. xxxv. 1816.) Pigs will not only eat coals, but keep in good condition upon them alone. Coals, however, are a vegetable substance. — Cuningham's *Two Years in New South Wales,* vol. i. p. 301.

of hunger ceases in a few days[h], probably from relaxation of the stomach through debility. But when hunger has ceased, though no food has been taken, weakness and sinking at the pit of the stomach are still felt.

Life may be supported for a certain time by nutriment introduced into the intestines. I lately attended a lady who, through obstruction of the œsophagus, attended by suppuration, *did not swallow a particle of solid or fluid for six weeks*, at the end of which she died. Three injections of milk, eggs, and wine, were employed daily. She passed a feculent soft evacuation in every twenty-four hours, and never felt the sensation of hunger.

A poor diet, even of vegetable matter, sometimes gives rise to symptoms of scurvy[i]; and famine is soon attended by epidemic fever.

The torment of thirst increases until drink is procured or moisture applied to the surface or inhaled: inflammation of the mouth and throat, and intense fever, at length ensue.[k]

If abstinence is not forced upon the system, but is absolutely a part of disease, it may, like suspension of respiration in morbid states of insensibility[l], and like immense doses of powerful medi-

[h] Among many other accounts of starvation, some of these facts may be seen in Captain Franklin's *Narrative of a Journey to the Polar Sea*, p. 465. sq. 427. London, 1823; where the dreadful force of hunger is too truly illustrated. Our countrymen devoured their old shoes, and any scraps of leather they possessed. (pp. 418. 429. 438. 479.). The putrid spinal marrow left in bones, picked clean by wolves and birds of prey, was esteemed a prize, though its acrimony excoriated the lips; the bones were also eaten up after being burnt (p. 426.); great part of a putrid deer was devoured on the spot (p. 421.); and to destroy, skin, and cut up a cow, was the work of a few minutes, after which the contents of the stomach and the raw intestines were at once devoured and thought excellent. (p. 407.) In the siege of Jerusalem and other ancient cities, we read of women driven by hunger to devour their offspring; and Captain Franklin was assured, near the Saskatchawan, that men and women were then living, who had destroyed and fed upon the bodies of their own families, to prevent starvation in very severe seasons. (p. 51.)

[i] See Sir George Baker's account of two women, in the *Transact. of the College of Physicians*, vol. ii.

[k] A horrid description of raging thirst will be found in the account of the black-hole of Calcutta. See *Annual Register*, 1758.

[l] An example of the impunity with which a long exclusion of air may be borne, when the system is in a morbid nervous state, may appear to advantage by the side of similar illustrations of the deprivation of food. "The story of Ann Green," says the Rev. Mr. Derham, "executed at Oxford, Dec. 14. 1650, is still well

cines in various diseased states, be borne with wonderful indifference; and this occurs chiefly among females. But the most extraordinary case that I recollect, stated upon unquestionable authority, is that of a young Scotchwoman, who laboured under an anomalous nervous affection, and, excepting that on two occasions she swallowed some water, received no nourishment whatever for eight years. She passed urine enough twice a week to wet a shilling, and for three years had no intestinal evacuation.[m]

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remembered among the seniors there: she was hang'd by the Neck near half an Hour, some of her Friends thumping her on the Breast, others hanging with all their Weight upon her Legs, sometimes lifting her up and then pulling her down again with a sudden Jirk, thereby the sooner to dispatch her out of her Pain, as the printed Account of her informs us. After she was in her Coffin, being observ'd to breathe, a lusty Fellow stampt with all his Force on her Breast and Stomach, to put her out of Pain. But, by the Assistance of Dr. Peity, Dr. Willis, Dr. Bathurst, and Dr. Clark, she was again brought to Life. I myself saw her many Years after, between which Time and the Date of her Execution she had, as I am inform'd, borne several Children." (*Physico-Theology*, p. 156.) Her nervous insensibility appears from another writer, who states, that "she neither remembered how the fetters were knocked off, how she went out of prison, when she was turned off the ladder, whether any psalm was sung or not, nor was she sensible of any pain that she could remember. What is most remarkable is, that she came to herself as if she had awakened out of a sleep, not recovering the use of her speech by slow degrees, but in a manner altogether, beginning to speak just where she left off on the gallows." (Plott's *History of Oxford.*)

[m] *Phil. Trans.* vol. lxvii. In a remarkable instance of imperfect abstinence during fifty years, the woman voided a little feculent matter like a piece of roll-tobacco, or a globule of sheep's dung, but once a year, and that always in March, for sixteen years. (*Edinb. Med. and Phys. Essays*, vol. vi.) It would be interesting to examine the changes induced in the air by the lungs and skin of such patients.

Pouteau mentions the case of one of his patients, a young lady thirteen years of age, who was affected with convulsions and insensibility at a certain period, generally every day, sometimes not quite so often, and great irritability of stomach, lived eighteen months, and grew more than two inches and a half, on syrup of capillaire and cold water. Here, the abstinence was not part of the disease, but the extraordinary state of the system enabled it to bear the abstinence. *Œuvres Posthumes*, t. i. p. 27.

Still, many cases of abstinence have been impostures and exaggerations; and I cannot illustrate this better than by quoting the case of Eue Fleigen, the Dutch prototype of our own Anne Moore of Tutbury. She contrived to deceive the world for fourteen years (from 1597 to 1611), pretending that she took no nourishment all that time. She had no nervous derangement to render food

For every example of extraordinary abstinence among females we have a counterpart in voraciousness among males. When the appetite is so great, it is seldom nice; and not only all animals in all states are devoured, but glass, flints, metals, sand, wood, &c. A Frenchman, named Tarare, and described by Drs. Percy and Laurent, in some measure from their own observation [n], will form a good contrast to the Scotch girl. When a lad, he once swallowed a large basket of apples, after some person had agreed to pay for them ; and at another time a quantity of flints, corks, and similar substances. The colic frequently compelled him to apply at the Hôtel Dieu : he was no sooner relieved, however, than he began his tricks again, and once was but just prevented from swallowing the surgeon's watch, with its chain and seals. In 1789 he joined the mob, and obtained sufficient food without devouring for money. He was then about seventeen, weighing a hundred pounds, and would eat five-and-twenty pounds of beef a day. When the war broke out he entered into the army, and devoured his comrades' rations, as long as better supplies from other sources rendered them of little value. But when at length his comrades stood in need of them themselves, he was nearly famished, fell ill, and was admitted into the *hôpital ambulant* at

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unnecessary; yet the minister and magistrates of Meurs made trial of her for thirteen successive days without detecting her imposture. Over her picture in the Dutch original are these lines : —

> Mueræ hæc quam cernis decies ter sexq ; peregit
> Annos, bis septem prorsus non vescitur annis
> Nec potat, sic sola sedet, sic pallida vitam
> Ducit, et exigui se oblectat floribus horti.

Thus rendered in the English translation —

> This maide, of *Meurs* 36 yeares spent
> 14 of which she tooke no nourishment
> Thus pale, and wan she sits sad and alone
> A garden 's all shee loves to looke upon.

An Apologie or Declaration of the Power and Providence of God. By George Hakewill. 1630. fol.

Respecting Anne Moore, see Dr. Henderson's *Examination*, &c.

[n] *Dictionnaire des Sciences Médicales*, art. Homophage ; where the dissection of another polyphagus is given, whose stomach was found to have been made neither more nor less than a collection of marine stores. See also Percy's *Mémoire sur le Polyphage*, in the *Journal de Médecine*, Brumaire, An xii.

Sultzer. He there ate not only a quadruple allowance, the broken food of the other patients, and the waste of the kitchen, but would swallow the poultices and any thing else that came in his way. He devoured so many dogs and cats alive that they fled at the sight of him. Large snakes he despatched with the greatest facility; and once gobbled up in a few moments all the dinner that was provided for fifteen German labourers, viz. four bowls of curd, and two enormous dishes of dough boiled in water with salt and fat. At another time, he disposed of thirty pounds of raw liver and lights in the presence of some general officers, who, finding that he could swallow a large wooden lancet case, took the partitions out, enclosed a letter in it, and made him swallow it, and proceed to the enemy's quarters for the purpose of discharging it by stool, and delivering the letter to a French colonel who had fallen into the hands of the Prussians. This he contrived to do, enclosed the answer in it, swallowed it again, made his escape, discharged the case again from his bowels, washed it, and presented it to Beauharnois and the other officers. Having, however, been well drubbed by the enemy, he refused any further secret service, and was readmitted into the hospital to be cured of his hunger. Being no longer a novelty, he excited less interest, and felt it necessary to have recourse to sheepfolds, poultry-yards, private kitchens, slaughter-houses, and by-places, where he had to contend with dogs and wolves for their filthy food. He was detected drinking blood that had been taken from his fellow-patients, and eating bodies in the dead-house. The disappearance of a young child excited strong suspicions against him, and he was at length chased away and unheard of for four years, at the end of which time he applied at the Hospice de Versailles, wasted, no longer voracious, and labouring under a purulent diarrhœa; and he soon died, aged twenty-six. The body immediately became a mass of putridity. During his life he was always offensive, hot, and in a sweat, especially at intervals. His breath rolled off like steam, and his dejections were constantly very copious, and intolerably fœtid. He was of the middle height, thin, and weak.

All the abdominal viscera were found full of suppurations.

His stomach was of immense size, and this has usually been the case in persons habitually gluttonous. A polyphagous idiot opened by the same writers displayed an enormous stomach, more resembling that of a horse than of a human being: the intestines

also formed several large pouches in succession, which appeared like additional stomachs. Cabrol dissected a glutton of Toulouse, and found the œsophagus terminating in an excessively large cavity, and the intestines running, without a single convolution, but with merely a gentle sigmoid flexure, to the anus. A large pylorus, or a very depending position of it, have been found in other cases. We thus learn the common causes of constitutional voraciousness, and obtain an additional reason for referring hunger to the want of distention of the stomach:—a great quantity of food is required to *fill* these stomachs. If hunger were independent of the distention of this organ, and connected solely with the want of the system, an ordinary meal would suffice where the stomach is very large, as the extraordinary quantity of food cannot be demanded for nourishment,—when food enough for support is taken, hunger should cease. But hunger continues till the stomach is filled, and the prodigious collection in the case of Tarare was disposed of by abundant stools, sweating, and copious pulmonary exhalation.

The large capacity of the stomach is generally ascribable to original conformation, but some account for it occasionally by repeated over-distention and the deglutition of indigestible substances,—an opinion rather improbable, when we reflect that corporation gluttons, who give a very fair trial to the distensibility of their idol, never acquire such appetites and capaciousness of stomach as qualify them for a show. The power of deglutition may be very much increased by practice. We have all seen the Indian jugglers; and I frequently conversed with a poor man who had swallowed nineteen large clasp-knives at different times, having found in a drunken fit that he could get one down his throat for a wager[o]: yet in him the appetite and capacity of stomach were not augmented. Knife and stone eaters are seen in all countries.

Some great eaters are prodigies of strength; as Milo, who killed

[o] Several pieces of the knives are preserved in the Museum of Guy's Hospital, and an account of the case may be found in the *Med. Chir. Trans.* vol. xii.

There is a collection of cases of extraordinary swallowing from Galen, Vesalius, Paré, &c., in Shenkius, *Observationes Medicæ*, lib. iii.

A polyphagus at the *Jardin des Plantes*, who once ate a lion which had died there of some disease, and at last died himself of eating 8lbs. of new bread, most originally conceived, being all for the belly, that animals might be classed according to their excrement, and actually made a collection of such stores, upon which he would descant most eloquently. *Dict. des Sc. Méd.*, Cas. Rares, p. 199.

an ox with a blow of his fist, and devoured it; and the fellow mentioned in a thesis published at Wittemberg in 1757, who once, in the presence of the senate, ate up a sheep, a sucking-pig, and sixty pounds of plums, stones and all, and could carry four men a whole league upon his shoulders.

Voracity is of course sometimes, like depraved appetite, as in chlorosis and pregnancy, but temporary, and referable to merely disordered function. Dr. Satterly details the case of a lad in whom, while labouring under typhus with marked inflammation in the head, the exacerbations of fever were accompanied by such hunger, that he ate every day four regular meals, each sufficient for the stoutest labourer's dinner, and many pounds of dry bread, biscuit, and fruit between them. He had no sooner finished a meal than he denied having tasted any thing,

——— "cibus omnis in illo,
Causa cibi est, semperque locus fit inanis edendo,"

and would suck and bite the bed-clothes or his fingers[p] if refused more, cared nothing about the quality of what he ate, would pass six or seven large solid motions a day by means of physic, and ultimately recovered.[q] The stomach here executed its office with excessive rapidity, and was too soon empty again.

To show how some animals differ from us in the demand for food, I may mention that the ant-lion will exist without the smallest supply of food, apparently uninjured, for six months; though, when he can get it, he will daily devour an insect of his own size. A spider has lived without food under a sealed glass for ten months, and at the end of that time appeared as vigorous as ever. Reptiles have often lived upwards of a century enclosed in trees or stones.

On the other hand, herbivorous larvæ, as caterpillars, (for insects are carnivorous, herbivorous, and omnivorous, like their superiors,) will eat twice their weight of food daily.[r]

[p] Ovid's account of Erisichthon is verified in many histories of voracity:—

"Ipse suos artus lacero divellere morsu
Cœpit; et infelix minuendo corpus alebat." *Metam.* lib. viii.

[q] *Transactions of the Royal College of Physicians, London,* vol. v. See also *Phil. Trans.* Papers read 1745; and Abridgment, vol. iii. p. 111.

[r] Kirby and Spence, *Entomology,* p. 398. sq.

"Although thirst is a violent desire, drink appears not very necessary to life and health; for many warm-blooded animals — mice, quails, parrots, &c. — do not drink at all; and some individuals of the human species have lived in perfect health and strength without tasting liquids."[s]

Sauvages mentions a member of the Academy of Toulouse who never thirsted, and passed whole months of the hottest summer without drinking; and a woman who passed 40 days without liquids or thirst.[t]

"It has been disputed whether our *food*, by which we satisfy these stimuli, is derived more advantageously, and the more consistently with nature, from the animal or from the vegetable kingdom.[u]

"Some contend that man is herbivorous, from the shape of his teeth[x], the length of his intestines[y], the difference between the structure of the small and large intestines, and from the cells of the colon, &c. Rousseau ingeniously urges the circumstance that woman is naturally uniparous and provided with two breasts.[z] To these arguments it may be added, that some men have ruminated,—a power peculiar to herbivorous animals[a], and that tame

[s] "See G. Baker, *Med. Transact. published by the Coll. of Physicians in London*, vol. ii. p. 265. sq."

[t] "*Nosol. Méthod.* t. i. p. 770.

See also *Eph. Nat. Cur.* c. v. and vi. p. 30."

[u] "J. W. Neergaard, *Vergleichende Anatomie und Physiologie der Verdauungswerkzeuge der Saügethiere und Vogel.* Berlin, 1806, p. 244."

[x] "Gassendi, *Letter* to J. Bapt. v. Helmont. Opera. Florence, 1727, fol. t. vi. p. 17. Al. Monro, senr. *Essay on Comparative Anatomy*, p. 17."

[y] "J. Wallis, *Phil. Trans.* No. 269."

[z] "*Sur l'Origine de l'Inégalité parmi les Hommes*, p. 196. sq."

[a] A striking instance of this occurred at Bristol. A *man* twenty years of age had, as long as he could remember, chewed his food a second time, after swallowing it. The process began in a quarter of an hour if he had taken liquid at his meal — later if he had not: and, after a full meal, lasted about an hour and a half. What had passed down first, always came up first. Before the second chewing, his food appeared to lie heavy in the lowest part of his throat: after it, "the food passed clean away." If he ate a variety, "that which passed down first came up first." He found the taste of the food on its return to be chewed rather pleasanter than at first. "If this faculty left him it signified sickness, and he was never well till it returned." His father had sometimes ruminated slightly. (*Phil. Trans.* Abridgment, vol. iii. p. 110. sq.)

vegetable feeders are easily accustomed to animal food; whereas carnivorous animals, excepting the dog, can very seldom be brought to feed on vegetables.

"The arguments of those who, with Helvetius [b], regard man as carnivorous, are derived from the conformation of his stomach, the shortness of his cæcum, &c.

"More careful observation, however, proves that man is not destined for either kind of food alone, but for both. His teeth, particularly the molares [c], and the peculiar structure of his intestines just alluded to, hold a middle rank between the same parts in the feræ and in herbivorous animals." In carnivorous animals, the incisors are very large; and the molares generally of an irregular wedge form, those of the lower jaw closing in those of the upper like scissors, and being adapted for lacerating. In the herbivorous, the surface of the molares is horizontal or oblique, adapted for grinding. As the food of herbivorous animals requires more preparation before it becomes the substance of the animal, their stomach is adapted to retain it for a length of time. The œsophagus opens nearer the right extremity of the stomach, and the pylorus nearer the left, so that a blind pouch is left on either side. In the carnivorous, the reverse is the case, and the stomach cylindrical, to favour the quick passage of the food. For the same reason, the intestines in the latter, even among insects, are generally shorter, and have fewer valvulæ conniventes, and in some instances no cæcum.

Blumenbach has seen four examples of this kind: in two the process was compulsory, in two it was optional. These subjects also were *males*, and had a real gratification in ruminating. *Comparative Anatomy*, translated by Messrs. Lawrence and Coulson, 2d edit. p. 88. A case of human rumination, in a *man*, has lately been seen at the London Hospital. *London Medical Gazette*, June 23. 1832.

[b] "*De l'Homme*, t. ii. p. 17."

[c] "The opinion of Broussonet is singular. He thinks the human molares closely resemble the teeth of herbivorous animals, and at the same time regards the incisores and canini as allied to those of the carnivorous tribes: and, after comparing the *number* of the molares with that of the other teeth, concludes that the quantity of vegetable food intended for man is to the quantity of animal food as 20 to 12.

"But on this calculation it follows, that infants, who have four molares only in each jaw, are destined to consume a larger portion of animal food than adults, since the proportion of the molares to the other teeth is in them as 8 to 12."

"The mode in which the condyles of the lower jaw are articulated with the temporal bones, demonstrates his destination for both kinds of food in the most striking manner." In animals which subsist on animal food, the condyles of the lower jaw are locked in an elongated glenoid cavity, and all rotatory motion thus prevented, as motion upwards and downwards is sufficient for the laceration of the food. In vegetable feeders the joint is shallow, so that a horizontal motion is allowed for grinding the food. Its nature in man is explained at the beginning of the next chapter.

"As the human race exists in more parts of the globe than any other kind of animal, we should have been but ill provided for if we had been destined to subsist on either description of food alone; whereas man now inhabits some countries which afford either vegetable or animal food only.

"Man is by far the most omnivorous of all animals, capable not only of feasting on luxurious combinations derived from each kingdom, but of subsisting with health and vigour on nearly one kind of the most simple food.

"Thus, to mention a very few instances, many at present live on vegetables only, as the tubera of solanum (potatoes), chestnuts, dates, &c. The first families of mankind most probably subsisted for a long period merely on fruits, roots, corn, and pulse.[d]

"The nomadic Moors have scarcely any other food than gum senega[e]:

[d] "Consult Heyne, *Opuscula Academ.* vol. i. p. 366. sq."

[e] "Adamson, *Mém. de l'Acad. des Sc. de Paris*, 1778, p. 16."

In 1750, a caravan of Abyssinians had consumed all their provisions, and would have starved but that they discovered among their merchandise a stock of gum-arabic, on which alone above a thousand persons subsisted for two months. (Hasselquist, *Voyages and Travels in the Levant*, p. 298.) Yet Dr. Magendie says he finds that dogs perish if fed only with gum or sugar, olive oil, butter, and similar articles, regarded as nutritious, which contain no azote. (*Annales de Chimie et de Physique*, vol. iii. p. 66. 1816.) But although such substances be alone unable to nourish, yet when united with others they may afford some support; for persons accustomed to a mixed diet generally grow thinner if they confine themselves to vegetable food, which is indubitably good nourishment: and even if we grant that such substances are not nutritious to dogs, they may be proper food for other species: and to render it probable even that these are not nutritious to dogs, the animals should have been gradually brought to feed on them only; for animals may be brought to live on food the most opposite to what their nature inclines them, if the change is made insensibly: — Spallanzani

"The inhabitants of Kamtschatka and many other shores scarcely any other than fish.

"The shepherds in the province of Caraccas in South America, on the banks of the Orinoko [f], and even the Morelachs [g] in Europe, live almost entirely on flesh.

"Some barbarous nations devour raw animals. This cannot be denied to have formerly been the case with the Samojedes [h], the Esquimaux [i], and some tribes of South America.[k]

"Other nations are no less remarkable in their drink.

"The inhabitants of many intertropical islands, especially in the Pacific Ocean, can procure no sweet water, and instead of it drink the juice of cocoa-nuts.

"Others take only sea-water; and innumerable similar facts clearly prove man to be omnivorous."

It appears that matter, as in the case of water, which has never belonged to an animated system, is calculated to afford nourish-

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made a pigeon live on flesh, and an eagle on bread. (*Expériences sur la Digestion*, c. lxxiv. c. lxxv.) If fresh-water mollusca are put at once into sea water, or sea-water mollusca into fresh water, they perish; but if the change is gradually made, they live very well. (*Annales de Chimie et de Physique*, vol. ii. p. 32. 1816.) A spider has fed upon sulphate of zinc. (Thomson's *Annals of Philosophy*, vol. xii. p. 454.) We have seen that the Otomacs eat little else some months of the year than large quantities of earth, and that some brutes devour earth. I may here add that not only the Otomacs are so fond of it, as, when well supplied with food, to take a little, but that many nations of the torrid zone have a propensity to geophagism. The negroes of Guinea, the Javanese, the New Caledonians, and many South American tribes, eat clay as a luxury; and the Guajeroes, on the west of Rio da la Hache, carry a little box of lime as sailors do a tobacco-box. German workmen at the mountain of Kiffhönser spread clay instead of butter on their bread, and call it *stein butter*, and find it very satisfying and easy of digestion. The Otomacs do not suffer by the practice, but in some tribes the people grow sick and thin by indulging too freely in this luxury. Africans who geophagised with impunity at home on a yellow clay, severely suffer from it in the West Indies. (See also Dr. John Hunter, *Diseases of the Army in Jamaica*, p. 248. sqq.) The red clay eaten in Java destroys the appetite and wastes the body.

[f] "Fil. Salv. Gily, *Saggio di Storia Americana*, vol. iv. p. 120."

[g] "Gius. Ant. Pujati, *Reflessioni sul Vita Pitagorico*. Feltri, 1751, 4to."

[h] "De Klingstaedt, *Mém. sur les Samojedes et les Lappons*. 1762, 8vo."

[i] "Curtis, *Phil. Trans.* vol. lxiv. p. ii. p. 381. 383."

[k] "J. Winter, in Hakluyt's *Principal Navigations of the English Nation*, vol. iii. p. 751."

ment to animals in some degree, but subordinately to matter which has belonged to vegetables or animals, and that it alone will in some instances support life for a time. Vegetables live chiefly on such, and will indisputably live for a time with facility on them alone, and some even if merely suspended in the air[l] (carbonic acid is, indeed, the great nourishment of all vegetables), but eventually will not thrive and perfect their seed, unless animal or vegetable remains exist in the soil; whence the necessity of this kind of manure, which must have likewise been so changed by putrefaction that its carbon has formed a compound resembling the extractive principle and thus capable of solution in water.[m] It has been contended that some animals, as fish, and that some vegetables, readily subsist, growing equally with others, and perfecting their seed or ova, on simple water; but the experiments in support of this assertion are not at all decisive.[n] None of these statements are affected by the derivation of *gaseous* substances from the surrounding air or water, by animals or vegetables.

The articles of diet generally employed by every nation and class of society are much determined by the facility with which they are procured. Generally, too, animal food is preferred in cold climates, and vegetable in warm: a mixture, however, of the two is usually preferred to either exclusively, and appears better suited to our necessities. Animal food is chiefly muscle and fat, milk and eggs; vegetable food, chiefly seeds and roots, fruits and leaves, with more or less of the stalks. These articles, which are rendered more or less masticable or digestible by heat, are previously subjected to high temperatures in various ways; and as many saline and aromatic substances are taken, not so much for their nutritive qualities and their undoubted assistance when the stomach is weak or chiefly vegetables are eaten, as for their sapid qualities, and since the admixture of these, and the combination

[l] Two fig plants (*Ficus australis* and *Ficus elastica*) have continued to send out shoots and leaves, the former for eight, the latter for fourteen, years, suspended in the hot houses of the Botanical Garden of Edinburgh. — *Elements of Chemistry*, by Dr. Turner, Professor of Chemistry in the University of London, 1833. p. 862. sq.

[m] Mould consists principally of carbon, combined with a little oxygen and hydrogen, and, if it be animal, with also a little azote, together with the usual saline ingredients of organised substances.

[n] Full information on this subject will be found in Dr. Thomson's *System of Chemistry*, book iv. ch. 3. sect. 2.

of various nutritive substances together, often highly increase the exquisiteness of taste and flavour, the culinary art is cultivated not only for health, but also for luxury.

The chief proximate principles of animal food are fibrin, albumen, gelatine, oil, and sugar; of vegetable, gluten, fecula, mucilage, oil, and sugar. My not less excellent than distinguished friend, Dr. Prout, in the paper which was honoured with the Copley medal of the Royal Society [o], reduces all the articles of nourishment among the higher animals to three classes: the saccharine, oily, and albuminous. The first comprehends sugars, starches, gums, acetic acid, and some other analogous principles; the second, oils and fats, alcohol, &c.; the third, fibrin, gelatine, albumen, and caseum or the curd of milk, with vegetable gluten, so abundant in wheat. He has favoured me with the following remarks, which are chiefly an abstract from a work on digestion, commenced by him in 1823, but not yet published.

"Observing that milk, the only article actually furnished and intended by nature as food, was essentially composed of three ingredients, viz. saccharine, oily, and curdy or albuminous matter, I was by degrees led to the conclusion that all the alimentary matters employed by man and the more perfect animals might, in fact, be reduced to the same three general heads; hence I determined to submit them to a rigorous examination in the first place, and ascertain, if possible, their general relations and analogies. An account of the first of these classes, viz. the saccharine matters, has been published in the *Philosophical Transactions*, and the others are in progress. The characteristic property of saccharine bodies is, that they are composed simply of carbon united to oxygen and hydrogen in the proportions in which they form water; the proportions of carbon varying in different instances from about 30 to 50 per cent. The other two families consist of compound bases (of which carbon constitutes the chief element) likewise mixed with and modified by water, and the proportion of carbon in oily bodies, which stand at the extreme of the scale in this respect, varies from about 60 to 80 per cent.; hence, considering carbon as indicating the degree of nutrition, which, in some respects, may be fairly done, the oils may be regarded in general as the most nutritious class of bodies; and the general conclusion from the whole is, that substances *naturally* containing

[o] *Phil. Trans.* 1827.

less than 30 or more than 80 per cent. of carbon are not well, if at all, adapted for aliment.

"It remains to be proved whether animals can live on one of these families exclusively; but at present experiments are decidedly against this assumption, and the most probable view is, that a mixture of two at least, if not of all three, of the classes of nutriment, is necessary. Thus, as has been stated, *milk* is a compound of this description, and almost all the gramineous and herbaceous matters employed as food by animals contain at least two of the three — the saccharine and glutinous or albuminous. The same is true of animal aliments, which consist, at least, of the albuminous and oleaginous: in short, it is, perhaps, impossible to name a substance employed by the more perfect animals as food, which does not essentially constitute a natural compound of, at least, *two*, if not of all *three*, of the above three great classes of alimentary matters.

"But it is in the artificial food of man that we see this great principle of mixture most strongly exemplified. He, dissatisfied with the productions spontaneously furnished by nature, culls from every source, and, by the power of his reason, or, rather, his instinct, forms, in every possible manner, and under every disguise, the same great alimentary compound. This, after all his cooking and art, how much soever he may be inclined to disbelieve it, is the sole object of his labour, and the more nearly his results approach to this, the more nearly they approach perfection. Thus, from the earliest times, instinct has taught him to add oil or butter to farinaceous substances, such as bread, which are naturally defective in this principle. The same instinct has taught him to fatten animals, with the view of procuring the oleaginous in conjunction with the albuminous principle, which compound he finally consumes, for the most part in conjunction with saccharine principles in the form of bread or vegetables. Even in the utmost refinements of his luxury and in his choicest delicacies, the same great principle is attended to, and his sugar and flour, his eggs and butter, in all their various forms and combinations, are nothing more nor less than disguised imitations of the great alimentary prototype, *milk*, as presented to him by nature."[p] It may be

[p] Consult also Dr. Prout's admirable *Bridgewater Treatise*, just published, in which will be found this and much other highly original and valuable matter.

worth reflecting, that children are particularly fond of saccharine substances, and dislike the oleaginous, at least fat.

More or less of common salt exists in the food of all animals. It is equally desired by the greater number, and many traverse immense tracts and encounter great difficulties to obtain it. Dr. Prout, I may mention, considers it, or the muriatic acid or chlorine which it affords, of the highest importance in the animal economy. How far a certain supply of other substances, as earths, metals, phosphorus, &c. from without is necessary, is not accurately known. Water is indispensable to vegetables and most animals.

Dr. Prout considers it as a general rule, subject, indeed, to many exceptions, that the food of organised beings is substances lower than themselves in the scale of organisation. Vegetables live chiefly on water and gases; and the animal or vegetable matters which also are their food, certainly must be in a state of entire decomposition. Some animals eat organised matter partly decomposed. The greater part live on animal or vegetable matter unchanged; and the animal matter is usually obtained from animals inferior in bulk or intelligence, — from animals with inferior powers of resistance. Man eats both animal and vegetable matter undecomposed, of infinite variety, all derived necessarily from beings inferior to himself. [q]

[q] M. Rastail, in a work published last year, at once profound, bold, and original, and containing the substance of various memoirs printed during the previous six years, entertains views very similar to those of Dr. Prout, though much more imperfect. He states, that proximate principles must be combined to become nutritious — that neither sugar nor gluten alone affords support, but that when combined they are alimentary. He offers the same objections to Dr. Magendie's conclusions respecting gum and other unazotised substances, which I have offered for many years. — *Nouveau Système de Chimie Organique, fondé sur des Méthodes Nouvelles d'Observation.* Par F. V. Rastail. Paris, 1833.

CHAP. II.

MASTICATION AND DEGLUTITION.

The food taken into the mouth, if solid, is reduced to a pulp by trituration and mixture with the fluids, and then passed into the stomach. The first process is termed *mastication* or *chewing;* the second, *deglutition* or *swallowing*.

"The lower jaw is the chief organ of mastication, and is supplied, as well as the upper, with three orders of teeth.

"With incisores, generally[a] scalpriform, for the purpose of biting off small pieces, and not placed in the lower jaw, as in other mammalia, more or less horizontally, but erect, — one of the distinctive characters of the human race.

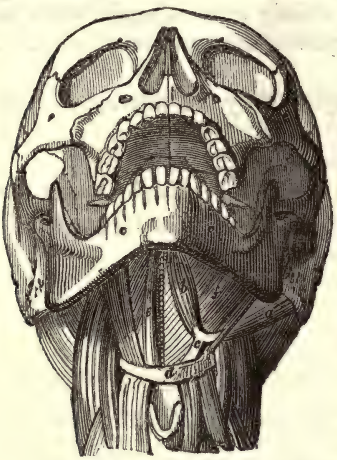
"With strong conical canine teeth, by which we divide hard substances, and which in man neither project beyond the rest, nor are placed alone, but lie closely and in regular order with the others.

"With molares of various sizes, adapted for grinding, and dif-

[a] "I say generally: for, without alluding to particular examples of their obtuseness, I may remark that I have found the crown of the incisors thick and obtuse in the skulls of most mummies. And since the more remarkable for this variety have resembled, in their general figure and appearance, the singular and never-to-be-mistaken physiognomy of the ancient Egyptians, observable in the idols, sarcophagi, and statues of ancient Egypt, it is probable that this peculiar form of the teeth, whether owing to diet or whatever else, was peculiar to the ancient Egyptians, and may be regarded as a national mark, or even as a characteristic by which true ancient mummies may be distinguished from those of late formation."

"I have written at large on this subject in the *Philos. Trans.* 1794. P. II. p. 184."

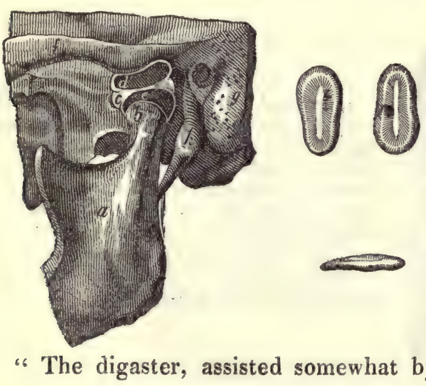
fering conspicuously from those of other mammalia, by possessing gibbous apices excessively obtuse.



The *four central* teeth in *both* jaws are the incisores: the *outer one* on *each* side in *both* is the canine: the *five outermost* on *each* side in *both* are the molares.

a, belly of the *digastric* arising at the root of the mastoid process of the temporal bone: *b*, belly arising below the symphysis of the lower jaw: *c*, tendon in which each ends: *d*, os hyoides, into which the tendon is inserted. If the os hyoides is fixed, the inner belly can lower the jaw: if the jaw is fixed, the os hyoides can be raised. *e*, genio-hyoideus: *f*, mylo-hyoideus.

" The lower jaw is connected with the skull by a remarkable articulation, which holds a middle rank between arthrodia and ginglymus; and, being supplied with two cartilaginous menisci of considerable strength, has easy motion in every direction." In other words, the condyles of the lower jaw are prevented from descending very deeply into the glenoid cavity; and are confined to vertical movements, by a cartilage which is hollow on each surface, and moveable, and permits the condyle to move from the glenoid cavity to a tubercle which stands before this, and thus to acquire still greater mobility.



a, outer part of the lower jaw: *b*, its condyle, pulled down from the glenoid cavity to show the joints: *c*, interarticular fibro-cartilage forming two menisci: *d*, upper synovial membrane: *e*, lower synovial membrane: *f*, zygoma: *g*, mastoid process: *h*, styloid process. The three other figures are a superior, an inferior, and a lateral, view of the interarticular cartilage.

" The digaster, assisted somewhat by the genio-hyoidei and

mylo-hyoidei muscles, draws the lower jaw down, when we open the mouth.

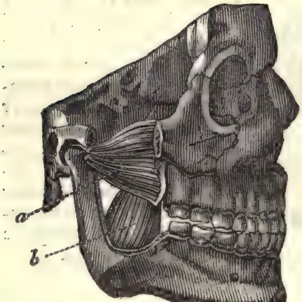
" The masseters and temporal chiefly raise it again when we bite off any thing, and are most powerfully contracted when we break hard substances.

" Its lateral motions are accomplished by the internal and external pterygoid.

" The latter can also draw it forwards.

" Substances are retained, directed, and brought under the action of the teeth, by the buccinator, and by the tongue, which is very flexible and changeable in form.

a, temporal muscle, inserted by a tendon into the coronoid process of the lower jaw: *b*, masseter arising from the zygoma, and inserted into the angle of the lower jaw: *c*, buccinator, or great muscle of the cheek, the action of which is to lessen the cavity of the mouth, and draw the angle of the lips backwards. The mere inspection of the other muscles shows their action. *d*, the parotid gland: *e*, its duct: *f*, a portion of the sub-maxillary gland uniting with the parotid.



a, external pterygoid, arising from the pterygoid process and zygomato-temporal surface of the sphenoid bone, and the tuberosity of the os palati, and inserted into the front of the neck of the condyle of the lower jaw, and interarticular cartilage. *b*, internal pterygoid, arising from the pterygoid fossa of the sphenoid bone, and from the pterygoid processes of the palate bone, and inserted within the angle of the lower jaw.

"During mastication, there occurs a flow of *saliva*[b], which is a frothy fluid," consisting, according to Berzelius, of

Water - - - - - -	992.9
A peculiar animal matter - - -	2.9
Mucus - - - - - -	1.4
Alkaline muriates - - - -	1.7
Lactate of soda and animal matter -	0.9
Pure soda - - - - - - -	0.2
	1000.0[c]

What Berzelius calls mucus, Dr. Thomas Thomson and Dr. Bostock regard as albumen. This mucus is insoluble in water, and, when incinerated, but not before, yields a large portion of phosphate of lime.[d]

According to an examination by Tiedemann and Gmelin, saliva, mixed with more or less mucus, consists of—

A peculiar matter termed salivary; osmazome; mucus;—all essential to its composition:

Sometimes a little albumen:

A little fatty matter, united with phosphorus:

Potass, united with acetic, phosphoric, sulphuric, hydro-chloric, and sulpho-cyanic acid;—all soluble salts:

A large quantity of phosphate, and a smaller of carbonate, of lime; a minute quantity of magnesia;—all three insoluble.

The solid contents amount to about $\frac{1}{25}$ per cent. The alkaline properties of saliva were before ascribed to a free alkali, and that alkali was supposed to be soda. In the dog the alkali is soda, very little potass being discoverable.[e]

M. Rastail remarks, that whatever other persons examine the saliva will have still other results, as different substances are mixed in it at different times, and names are given to the mixture the elements of which are not determined. He discovers that the

[b] "J. Barth. Siebold, *Historia Systematis Salivalis.* Jen. 1797. 4to."

[c] J. Berzelius, *Medico-Chirurgical Transactions,* vol. iii. p. 242.

[d] The tartar of the teeth arises from its gradual decomposition upon them, and consists, according to Berzelius, of

Earthy phosphates - - -	79.0
Undecomposed mucus - - -	12.5
Peculiar salivary matter - - -	1.0
Animal matter soluble in muriatic acid -	7.5
	100.0

[e] *Die Verdauung nach Versuchen,* &c. By Fred. Tiedemann and Leopold Gmelin, Professors in the University of Heidelberg.

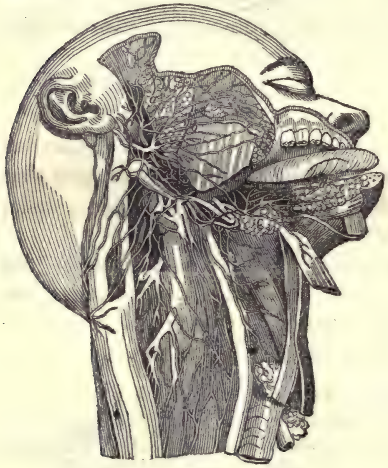
mucous membranes are constantly shedding and renewing, like the epidermis, from their cells successively shrivelling; and that saliva taken before breakfast, and examined with the microscope, presents such membranous particles, which are the animal matter mentioned by chemists, and soluble only in hydrochloric (muriatic) acid. He adds, that, besides muriate of soda, it contains muriate of ammonia; and as to the lactates, he proves that lactic acid is only a combination of albumen and acetic acid. The quantity of ammonia, salts, and membranous particles varies, and is much greater before breakfast. He considers the saliva to be an albuminous solution, mixed with membranous fragments and salts, which affect its solubility in water.[f]

"The saliva flows from three orders of conglomerate glands, placed laterally and interiorly with respect to the lower jaw.

"The *parotids*[g] are the largest, and pour forth the saliva behind the middle molares of the upper jaw, through the Stenonian ducts:[h]

"The *submaxillary*[i], through the Whartonian:[k]

"The *sublingual*[l], — the smallest, through the numerous Rivinian.[m]



a, parotid gland: *b*, parotid duct: *c*, submaxillary gland: *d*, submaxillary duct: *e*, sublingual gland.

[f] l. c., p. 454. sq.

[g] "See De Courcelles, *Icones Musculorum Capitis*, tab. I. *g. h.*"

[h] "Stenonis, *Observationes Anatomicæ*, p. 20."

[i] "De Courcelles, l. c. tab. II. *t. t.*"

[k] "Wharton, *Adenographia*, p. 120."

[l] "De Courcelles, tab. v. *g. g. g.*"

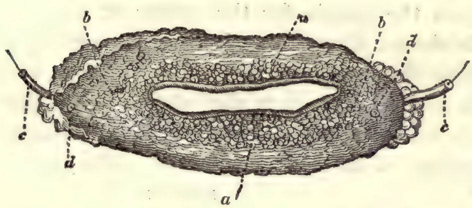
[m] "Rivinus, *De Dyspepsia*. Lips. 1678. 4to.
Aug. Fr. Walther, *De Lingua Humana*, ib. 1724. 4to."

"The excretion of saliva, amounting, according to the arbitrary statement of Nuck [n], to a pound in twelve hours, is augmented by stimuli and by mechanical pressure, or, if the term may be allowed, emulsion.

"The latter cause, greatly favoured by the situation of the parotids, at the articulation of the jaws, occurs when we chew hard substances, which thus become softened.

"The former occurs when acrid substances are taken into the mouth, which are thus properly diluted; or arises from imagination, as when the mouth waters during the desire for food.

"The mucus of the labial and buccal glands [o], and of the



Inner part of lips. *a a*, labial glands: *b*, buccal glands: *c c*, parotid ducts: *d d*, their orifices.

tongue, as well as the moisture which transudes from the soft parts of the mouth, is mixed with the saliva.

"The mixture of these fluids with a substance which we are chewing, renders it not only a pultaceous and easily swallowed bolus, but likewise prepares it for further digestion and for assimilation.

"The mechanism [p] of deglutition, although very complicated, and performed by the united powers of many very different parts, amounts to this:—the tongue being drawn towards its root, swelling and growing rigid, receives the bolus of food upon its dorsum, which is drawn into a hollow form. The bolus is then rolled into the isthmus of the fauces, and caught with a curious and rather violent effort by the infundibulum of the pharynx, which is enlarged and in some measure drawn forward to receive it. The three constrictores [q] muscles of the pharynx drive it into the œsophagus. These motions are all per-

[n] "Nuck, *Sialographia*, p. 29. sq."

[o] "De Courcelles, l. c. tab. IV. *e. e. e.*"

[p] "Fr. Bern. Albinus, *De Deglutitione*. LB. 1740. 4to.
P. J. Sandifort, *Deglutitionis Mechanismus*. Lugd. Batav. 1805. 4to."

[q] "Eustachius, tab. XLII. fig. 4. 6.
Santorini, *Tab. Posthum.* VI. fig. 1.
B. S. Albinus, *Tab. Musculor.* XII. fig. 23, 24."

formed in very rapid succession, and require but a short space of time.

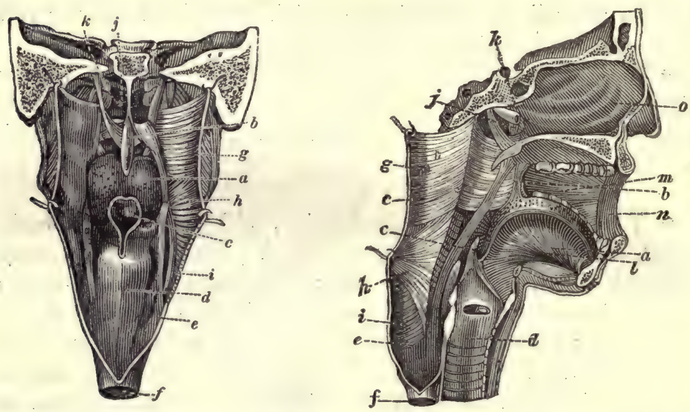
"Nature has provided various contrivances for opening and securing this passage.[r]

"The important motion of the tongue is regulated by the os hyoides.

"The smallest particle of food is prevented from entering the nostrils or Eustachian tubes, by means of the soft palate[s], which, as well as the uvula suspended from its arch, and whose use is not clearly understood, is extended by muscles of its own, and closes those openings.[t]

"The tongue protects the glottis, for the larynx at the moment of deglutition is drawn upwards and forwards, and in a manner concealed under the retracted root of the tongue, and applied to the latter in such a way, that the glottis, being also constricted, and protected by the epiglottis, is most securely defended from the entrance of foreign substances." The glottis,

POSTERIOR VIEW. LATERAL VIEW.



Posterior and lateral views of the throat. *a*, the tongue: *b*, palato-staphyline muscles, forming the uvula: *c*, epiglottis: *d*, larynx: *e*, pharynx: *f*, beginning of œsophagus: *g*, constrictor superior of pharynx turned back: *h*, constrictor medius: *i*, constrictor inferior: *j*, posterior opening of nostrils: *k*, opening of Eustachian tube: *l*, genio-glossus muscle: *m*, buccinator: *n*, orbicularis labiorum: *o*, cavity of the nostrils.

[r] "J. C. Rosenmüller, *Icones Chirurgico-Anatomicæ*. Fasc. 1. Vinar. 1805. fol."

[s] "Littre, *Mém. de l'Acad. des Sc. de Paris*, 1718. tab. xv."

[t] "Santorini, *Tab. Posthum.* IV—VI. fig. 2. —and VII.
B. S. Albinus, *Tab. Musculor.* XII. fig. 11. 27, 28."

however, when sound, may be sufficiently closed by the transverse and oblique arytænoid muscles, independently of the epiglottis. Dr. Magendie says that he saw two persons perfectly destitute of epiglottis, who always swallowed without difficulty.[u] Targioni also met with one, and in that case neither deglutition nor speech was impaired.[x]

" Deglutition is facilitated by the abundance of mucus which lubricates these parts, and which is afforded not only by the tongue, but by the numerous sinuses[y] of the tonsils and muciparous cryptæ of the pharynx.

" The *œsophagus*, through which the food must pass previously to entering the stomach, is a fleshy canal, narrow and very strong, mobile, dilatable, very sensible, and consisting of coats resembling, except in thickness, the coats of the other parts of the alimentary canal.[z]

" The external coat is muscular, and possesses longitudinal and transverse fibres.

" The middle is tendinous, lax, and more and more cellular towards each of its surfaces, by which means it is connected with the two other coats.

" The interior is lined, like all the alimentary tube, with an epithelium analogous to cuticle, and is lubricated by a very smooth mucus.

" This canal receives the approaching draught or bolus of food, contracts upon it, propels it downwards, and, in the case of the bolus, stuffs it down, as it were, till it passes the diaphragm and enters the stomach."

Professor Hallé observed in a woman, the interior of whose stomach was exposed by disease, that the arrival of a bolus of food in the stomach was followed by an eversion of the mucous membrane of the œsophagus into it, as we notice in the case of the rectum when a horse has finished discharging its fæces.[a]

[u] Magendie, *Précis Elément.*

[x] Morgagni, xxviii. 13.

[y] " B. S. Albinus, *Anotat. Acad.* l. III. tab. III. fig. 1. *n.*"

[z] " See Math. Van. Geuns, *Verhandelingen van de Maatschappye te Haarlem*, t. xi. p. 9. sq.

" Jan. Bleuland, *Observ. de Structura Œsophagi.* LB. 1785. 4to."

[a] Magendie, *Précis Elémentaire.*

a, soft palate: *b*, anterior pillars of soft palate: *c*, posterior pillars of soft palate. The space between them is called the fauces. *d*, uvula: *e*, upper part of trachea: *f*, œsophagus, the upper part having been cut away to shorten the drawing: *g*, cardia: *h*, pylorus, the space between *g* and *h* being the cavity of the stomach: *i i*, duodenum: *k*, hepatic duct: *l*, gall bladder: *m*, cystic duct: *n*, ductus communis choledochus, formed of the two: *o*, the opening of the choledochus into the duodenum: *p*, pancreatic duct; *q*, its opening into the duodenum, which here is distinct from that of the choledochus: *r*, jejunum: *s*, ilium: *t*, termination of ilium in cæcum: *u*, superior fold of valve of colon; *v*, inferior of ditto: *w*, cæcum: *x*, vermiform process: *y y*, colon: *z*, rectum: 1, part of levatores ani: 2, anus.

CHAP. III.

DIGESTION.

"The *stomach* is the organ of digestion. It exists, what cannot be affirmed of any other viscus, in, perhaps, all animals without exception; and, if the importance of parts may be estimated in this way, evidently holds the first rank among our organs.

"The human stomach[a] resembles a very large leathern bottle, is capable, in the adult, of containing three pints and upwards of water, and has two openings.

"The superior, called *cardia*, at which the œsophagus, folded and opening obliquely, expands into the stomach, is placed towards the left side of its fundus.

"The inferior, at which the right and narrow part of the stomach terminates, is called *pylorus*, and descends somewhat into the cavity of the duodenum.

"The situation of the stomach varies accordingly as it is in a state of repletion or depletion. When empty, it is flaccid, and hangs into the cavity of the abdomen, its greater curvature inclining downwards, while the pylorus, being directed upwards, forms, by doubling, an angle with the duodenum.[b]

"When full, the larger curvature is rolled forwards[c], so that the pylorus lies more in a line with the duodenum, while the cardia, on the contrary, is folded, as it were, into an angle and closed.

"The stomach is composed of four principal coats, separated by the intervention of three others, which are merely cellular.

"The *external* is common to nearly all the alimentary canal, and continuous with the omentum, as we shall presently mention.

"Within this, and united to it by cellular membrane, lies the *muscular* coat, which is particularly worthy of notice from being

[a] "Eustachius, tab. x. fig. 1, 2, 3.
Ruysch, *Thes. Anat.* ii. tab. v. fig. 1.
Santorini, *Tab. Posth.* xi."

[b] "Vesalius, *De c. h. Fabrica.* L. v. fig. 14, 15."

[c] "Id. l. c. fig. 2."

the seat of the extraordinary irritability of the stomach. It consists of strata of muscular fibres[d], commonly divided into three orders, one longitudinal and two circular (straight and oblique), but running in so many directions that no exact account can be given of their course.

"The third is the chief membrane. It is usually termed *nervous*, but improperly, as it consists of condensed cellular membrane, more lax on its surfaces, which are united, on the one hand, with the muscular, and, on the other, with the internal villous coat. It is firm and strong, and may be regarded as the basis of the stomach.

"The *interior* (besides the epithelium investing the whole alimentary canal), improperly called villous, is extremely soft, and in a manner spongy, porous, and folded into innumerable rugæ[e], so that its surface is more extensive than that of the other coats; it exhibits very small cells[f], somewhat similar to those larger cells which are so beautiful in the reticulum of ruminants.

"Its internal surface is covered with mucus, probably secreted in the muciparous crypts which are very distinct about the pylorus.

"The stomach is amply furnished with nerves[g] from each nervous system, whence its great sensibility, owing to which it is so readily affected by all kinds of stimuli, — whether external, as cold, — or internal, as food and its own fluids, — or mental; whence also the great and surprising sympathy between it and most functions of the system; to which sympathy are referable the influence of all passions upon the stomach, and of the healthy condition of the stomach upon the tranquillity of the mind.[h]

"The abundance and utility of the blood-vessels of the stomach are no less striking. Its arteries, ramifying infinitely upon the cellular membrane and glands, secrete the *gastric juice*, which would appear to stream continually from the inner surface of the stomach.[i]

"In its general composition this fluid is analogous to the saliva

[d] "Besides Haller, consult Bertin, *Mém. de l'Acad. des Sc. de Paris*, 1761."

[e] "Ruysch, *Thes. Anat.* ii. tab. v. fig. 2, 3, 4*."

[f] "See G. Fordyce, *On the Digestion of Food*, p. 12. 59. 191."

[g] "Walter, *Tab. Nervor. Thorac. et Abdom.* tab. iv."

[h] "J. H. Rahn, *Mirum inter Caput et Viscera Abdominis Commercium.* Gotting. 1771. 4to.

Dit. Vegens, *De Sympathia inter Ventriculum et Caput.* LB. 1784. 4to.

Wrisberg, *Commentat. Societ. Scientiar. Gotting.* t. xvi."

[i] "Ever. Home, *Phil. Trans.* 1817. p. 347. tab. xviii. xix."

equally antiseptic, very resolvent [k], and capable of again dissolving the milk which it has coagulated.[l]

"Digestion is performed principally by it. The food, when properly chewed and subacted by the saliva, is dissolved [m] by the gastric fluid, and converted into the pultaceous chyme; so that most kinds of ingesta lose their specific qualities, are defended from the usual chemical changes to which they are liable, such as putridity, rancidity, &c., and acquire fresh properties preparatory to chylification.[n]

"This important function is probably assisted by various accessory circumstances. Among them, some particularly mention the *peristaltic motion*, which, being constant and undulatory, agitates and subdues the pultaceous mass of food.[o] The existence

[k] "Ed. Stevens, *De Alimentorum Concoctione.* Edinb. 1777. 8vo.
Laz. Spallanzani, *Dissertazioni di Fisica Animale e Vegetabile.* Modena. 1780. 8vo. vol. i."

[l] "Consult Veratti, *Comment. Instituti Bononiens.* tom. vi."
Seven grains of the inner coat of a calf's stomach were found by Dr. Young of Edinburgh to enable water poured upon it to coagulate 6857 times its weight of milk. Thomson's *System of Chemistry*, vol. iv. p. 596. ed. 6., and Fordyce *On Digestion*, p. 58.

[m] "Even the stomach itself, when deprived of vitality, has been found acted upon, and, as it were, digested, by it. See John Hunter, *On the Digestion of the Stomach after Death. Phil. Trans.* vol. lxii." This occurs particularly in the splenic portion, and a complete opening is sometimes made, with pulpy ragged edges, and the neighbouring organs with which the gastric juice comes in contact may be also corroded. It happens chiefly to persons and brutes who have been cut off in good health soon after taking food, and is observed also in vegetable feeders and fish. Some have ignorantly doubted this, and confounded it with softening from disease. Dr. Camerer of Stuttgard, in 1818, proved the accuracy of J. Hunter's opinion, by observing this softening to occur without putrefaction in brutes killed in good health, and putrefaction of the body to occur without softening of the stomach; and by ascertaining that the fluid, taken from a stomach which it had softened, produced the same change in another dead stomach to which it was transferred, but none upon another during life, though it immediately softened this stomach when the animal was killed, or both pneumogastric and trisplanchnic nerves were divided. This division alone produced no such effect. See Andral, *Précis d'Anatomie Pathologique*, t. ii. p. 86. sqq. A good paper, by Dr. Carswell, Professor of Morbid Anatomy in the London University, will be found in the *Journal Hebdomadaire*, Nos. 87. and 91., and the *Edin. Med. and Surg. Journ.*, 1830.

[n] "Consult Ign. Doellinger, *Grundriss der Naturlehre des menschlichen Organismus*, p. 88."

[o] "Consult Wepfer, *Cicutæ Aquaticæ Historia et Noxæ*, in innumerable places."

of a true peristaltic motion in the stomach during health, is, however, not quite certain; indeed, the undulatory agitation of the stomach that occurs, appears intended for the purpose of driving the thoroughly dissolved portions downwards, while those portions which are not completely subacted are repelled from the pylorus by an antiperistaltic motion.

"The other aids commonly enumerated, are the pressure on the stomach from the alternate motion of the abdomen, and the high temperature maintained in the stomach by the quantity of blood in the neighbouring viscera and blood-vessels, which temperature was at one time supposed to be of such importance, that the word coction was synonymous with digestion."

It was once imagined that fermentation, and once that trituration, was the cause of digestion, but, as neither can produce the same effects on food out of the body that occur in the stomach, these opinions fell to the ground. Besides, no signs of fermentation appear when digestion is perfect; and food, either defended from trituration by being swallowed in metallic spheres perforated to admit the gastric juice[p], or immersed in gastric juice out of the body[q], is readily digested.

[p] The Abbe Spallanzani and Dr. Stevens made such experiments upon brutes: but the latter experimented upon a man also, who was in the habit of swallowing stones and rejecting them, and who of course found no difficulty in doing the same with metallic balls.

[q] Experiments of this kind were made by Spallanzani, who procured the gastric juice by causing hungry animals to vomit, or by introducing a sponge into the stomach. But still more marked results were lately obtained in the case of a lad who had a fistulous opening from the stomach, in consequence of a wound through which, by means of a hollow bougie and elastic bottle, gastric juice was procured at pleasure. A portion of beef was introduced into the stomach on a thread and withdrawn for comparison, at the same time that a similar portion was plunged into a phial of gastric juice, the temperature of which was kept steadily in a sand-bath at 100°, — the degree of the stomach's temperature, ascertained by the introduction of a thermometer. The portion in the phial became completely dissolved, though more slowly than that in the stomach; probably from the latter being supplied with a succession of fresh gastric juice, and freely exposed to it by motion; for the action of the fluid is only on the surface, and a portion of chicken placed in a phial of gastric juice, for a similar experiment, was more quickly acted upon if agitated. The gastric juice, when first obtained, was almost as clear as water, and its antiseptic power was shown by the solutions of beef and chicken remaining a whole autumnal month without fœtor or sour taste. *American Medical Recorder*, January, 1826. Spallanzani and others found, that if gastric juice is applied to putrescent matter, it removes the fœtor and suspends putrefaction.

"To determine the time requisite for digestion is evidently impossible, if we consider how it must vary according to the quality and quantity of the ingesta, the strength of the digestive powers, and the more or less complete previous mastication.

"During health, the stomach does not transmit the digestible parts of the food before they are converted into a pulp. The difference of food must therefore evidently cause a difference in the period necessary for digestion.[r] It may, however, be stated generally, that the chyme gradually passes the pylorus in between three and six hours after our meals."

"The *pylorus*[s] is an annular fold, consisting, not like the other rugæ of the stomach, of merely the villous, but also of fibres derived from the nervous and muscular, coats. All these, united, form a conoidal opening at the termination of the stomach, projecting into the duodenum, as the uterus does into the vagina, and, in a manner, embraced by it."

The digestive process does not go on equally through the whole mass of food, but takes place chiefly where this is in contact with the stomach, and proceeds gradually from the surface to the centre of the mass; so that the food at the centre is entirely different in appearance from that at the surface, and, as soon as a portion is reduced to a homogeneous consistence, it passes into the duodenum without waiting till the same change has pervaded the whole.[t]

Dr. Prout considers the *solution* of the food to be a common chemical process, and to depend principally upon the *combination* of water with the alimentary substance by means of the gastric juice. He has shown that this part of the functions of the stomach is quite distinct, and may exist or be absent independently of the *assimilating* process. Thus, in some forms of dyspepsia, the solvent powers of the stomach are almost entirely suspended, so that the patient, though he may be able to assimilate pulpy matters, is quite unable to digest any thing solid; while in diabetes, the solvent power of

[r] "Consult J. Walaeus, *De motu Chyli*, p. 534. LB. 1651. 8vo."

[s] "H. Palm. Leveling, *Dissert. sistens Pylorum, &c.* Argent. 1764. 4to. Reprinted in Sandifort's *Thes.* vol. iii."

[t] Dr. Prout, in *The Annals of Medicine and Surgery*, Lond. 1817., also in Thomson's *Annals of Philosophy*, 1819.

Dr. Wilson Philip, *An Experimental Inquiry into the Laws of the Vital Functions, &c.* 1826. p. 121. sqq. 3d edit. Dr. Philip published subsequently to Dr. Prout's first paper.

the stomach is often inordinately increased, and every article dissolved as soon as swallowed.[u]

Dr. Prout points out that hydrogen and oxygen *essentially* exist in many animal and vegetable proximate principles in the proportions which form water; in fact, that water essentially constitutes a part of them. This *essential* water is distinct from that which is accidental and makes the substance moist or fluid. If a large portion of water enters into their composition, the compound is *weaker* and *more easily decomposed.* Thus cane sugar consists of fifty-four parts of carbon with seventy-two of water: the weak sugar of honey consists of fifty-four parts of carbon with one hundred and eight of water. We cannot at pleasure lessen or augment the quantity of this essential water, and so alter the strength of the compound. The same holds in regard to the influence of water in all organised bodies. Thus strong, fixed, and solid oils have a very small constituent portion of water, and a large proportion of olefiant gas; while alcohol, the weakest form of the oily principle, perfectly soluble in water, contains more weight of water than half the weight of the olefiant gas.

Dr. Prout contends that the first stage of digestion is the solution and reduction of the proximate principles of various substances, by means of water and the muriatic acid of the stomach, to their weakest condition, — to that condition in which they are the most easily decomposed and brought into new combinations. The effect of good cookery is to facilitate this reduction of the proximate principles in the stomach to the weaker form;[x] for although we cannot by art make a weak compound strong (except, indeed, by lessening the water, incidentally moistening or dissolving it,) we are able in some measure to make a

[u] *Bridgewater Treatise,* by Dr. Prout.

[x] Continental cookery is superior to ours for weak stomachs, as far as it reduces substances to a pulp; but in the use of so much pure oil and pure sugar it is injurious, Dr. Prout remarks, to weak stomachs. For nature does not furnish sugar, starch, &c. or oil pure, but in combination. The purer we employ them, and especially those which are crystallizable, the more refractory is our food. Pure sugar, pure alcohol, and pure oil, are much less easy to be digested by the *healthy* stomach than substances purely amylaceous, or than that peculiar condition or mixture of alcohol existing in natural wines; or than butter. In these forms, the assimilation of the saccharine and the oleaginous principles is comparatively easy. Prout, l. c. p. 507. sq.

strong compound weak. The substance of young animals consists generally of weaker compounds than that of old, and is therefore tenderer and easier of digestion. Besides this reduction to a weaker state, the articles of food in general are more or less dissolved in the stomach.

After the solution of the food and the reduction of its proximate principles to the weaker forms, the stomach possesses the power of conversion, or of changing the proximate principles of the food into others, so that a fluid, called chyle, of pretty uniform composition, is obtained from it. Thus, it would appear, that the various substances belonging to the classes of saccharine, albuminous, and oleaginous, are all convertible into each other, some out of the body, some only within it. The albuminous and oleaginous require little change; and although the saccharine must require more, we ought to remember that sugar spontaneously becomes alcohol out of the body, and that alcohol is merely an oleaginous substance of a weak kind, and therefore probably undergoes in the stomach a similar series of changes to those which, out of the body, convert it to alcohol.[y]

The cardiac portion of the stomach is the chief seat of digestion, and when a part of the food is tolerably digested it passes along the large curvature to the pyloric portion, where the process is completed. As the cardiac half is the great digesting portion, it is this half that is found sometimes to have been dissolved by the gastric juice after death; its contents are much more fluid than those of the pyloric half; and Dr. Philip, who by the dissection of about a hundred and thirty rabbits has been enabled to furnish the completest account of what goes on in the stomach, relates the case of a woman who had eaten and properly digested to the last, but whose stomach was ulcerated every where except at the cardiac end. Sir Everard Home says he found that fluids which had been drunk were chiefly contained in the cardiac portion, and, like many others, for upwards of a century and a half[z], that, if the body was examined early after death, the two portions of the stomach were frequently in fact divided by a muscular contraction.[a] Dr. Haighton observed the same

[y] Dr. Prout, l. c. p. 498. sqq.

[z] See Dr. Monro (Tertius), *Outlines of the Anatomy of the Human Body in its sound and diseased State*, vol. ii. p. 111. 1813.

[a] *Phil. Trans.* 1808.

hour-glass contraction in a living dog, and remarked the peristaltic motion to be much more vigorous in the pyloric half.[b]

Van Helmont asserted that the food becomes sour by digestion, but this was afterwards denied, and acidity said never to happen except in cases of disorder. Sir Gilbert Blane, many years ago, however, declared that he had "satisfied himself that there is such an acid (the *gastric*) by applying the usual tests to the inner surface of the stomach of animals. This property in ruminating animals," he added, "is confined to the digesting stomach."[c] Dr. Prout has discovered that the acid generated is the muriatic, both free and in combination with alkalies.[d] Tiedemann and Gmelin soon afterwards found the same thing, though without knowing, they assure us, Dr. Prout's discovery. They assert the clear ropy fluid of the stomach, or gastric juice, without food, to be nearly, or entirely, destitute of acidity, while the presence of food, or of the most simple stimulus to the mucous membrane, occasions it to become acid, and more so, according to the greater indigestibility of the food. The acid is very copious. They also assert the presence of acetic acid; but Dr. Prout believes this to be either the result of irritation or of disease, or occasionally to be derived from the aliment, and consequently to be neither necessary nor ordinary. The general change of the aliment in the stomach appears a greater or less approach to the nature of albumen, but Dr. Prout has been unable to detect true and perfect albumen there when none has been taken.

Brutes have been the subjects of these experiments; chiefly the rabbit, horse, dog, and cat.

Besides the labours of Dr. Prout, and of the professors of Heidelberg, a work has been published on all the subjects of chymification and chylification by MM. Leuret and Lassaigne, contradictory in many respects to the results of the others; but, knowing as I do the extreme accuracy of Dr. Prout in experimenting and deducing, and seeing that Tiedemann and Gmelin have bestowed infinite labour in repeating, varying, and extend-

[b] *Transactions of the Medical Society of London*, vol. ii. 1788. In the lion, bear, &c., the stomach is usually found divided by a slight contraction at its middle, and in some animals of the mouse kind by a slight elevation of its inner coat.

[c] *Transactions of a Society for the Improvement of Medical and Surgical Knowledge*, vol. ii. p. 138. sq.

[d] *Phil. Trans.* 1824.

ing their experiments, and have detailed all their proceedings, while the French writers merely give results, and appear to have bestowed far less pains, I must be excused for merely mentioning their work.[e]

The inspection of living animals shows, that, during chymification the mucous membrane of the stomach, and during chylification that of the small intestine, becomes strikingly red ; and if an animal is killed during either process, this redness is seen in the corresponding portion of the coat.[f]

[e] *Recherches Physiologiques et Chimiques pour servir à l'Histoire de la Digestion.* Paris, 1825.

An immense number of curious facts respecting different articles of food, and many points on the subject of digestion, will be found in the German work, and a good history of opinions in the French.

[f] Andral, *Précis d'Anatomie Pathologique,* t. ii. P. i. p. 6.

In granivorous birds the food passes into the crop, and from this into a second cavity, from which it enters the gizzard, — a strong muscular receptacle, lined by a thick membrane, in which, instead of having been masticated, it is ground by means of pebbles and other hard bodies swallowed instinctively by the animal ; hence true salivary glands do not exist about the mouth of birds, but abound in the abdomen, opening into the lower part of the œsophagus and into the crop and gizzard. In carnivorous birds, the gizzard is soft and smooth. The fluids of both crop and gizzard contain a free acid, according to Tiedemann and Gmelin, which is the muriatic or acetic.

Some graminivorous quadrupeds with divided hoofs have four stomachs, into the first of which the food passes when swallowed, and from this into the second. It is subsequently returned by portions into the mouth, chewed, and again swallowed, when, by a contraction of the openings of the two first stomachs, it passes over them into the third, and from this goes into the fourth. The process can be delayed at pleasure when the paunch is quite full. Some birds and insects also *ruminate.* The same chemists found the fluids of the two first stomachs alkaline, and of the third and fourth, acid. The stomachs of some insects and crustacea contain teeth. Some zoophytes are little more than a stomach, the food taken into it being chiefly dissolved and absorbed, and the refuse expelled at the orifice by which it had entered: others have several openings on the surface leading by canals that unite and run to the stomach, — a structure called by Cuvier, *mouth-root.* In regard to vegetables, it is not the whole root which absorbs, but the minute fibrous prolongations, which are called *spongioles.* Some roots are also reservoirs of nourishment. Between the most distinct kinds of stomach we see numerous intermediate varieties. The cardiac half of the interior of the stomach of the horse, for example, is covered by cuticle, and appears merely recipient, while the pyloric half is villous and digestive ; and the state of the contents in each half is, therefore, very different : a link thus existing between such stomachs as the human and the ruminating.

Vomiting cannot occur unless the stomach have the resistance of the diaphragm and abdominal muscles, or of something in their stead. Above a century and a half ago, enquirers began to make the horrid experiment of giving an emetic to an animal, and, after the abdominal muscles were cut away, observing how fruitless were all the efforts of the stomach to reject its contents till they applied their hands in place of these muscles, when, the stomach being forced by the diaphragm against the resistance, vomiting was instantly accomplished. From these experiments, Bayle, Chirac, Schwartz, Wepfer, &c. inferred that vomiting could not occur without the assistance of the diaphragm and abdominal muscles. Haller, *Element. Physiol.* lib. xix. § xiv. Afterwards J. Hunter said, "We know that the action of vomiting is performed entirely by the diaphragm and abdominal muscles." *On certain Parts, &c.* p. 199. Again, on the other hand, Dr. Magendie finds that if the stomach is removed, and a pig's bladder substituted and connected with the œsophagus the retching induced by injecting tartarized antimony into the veins, causes the diaphragm and abdominal muscles to compress it sufficiently to expel its contents into the mouth. *Mémoire sur le Vomissement,* and *Précis Elémentaire.* The division of the par vagum, which supplies the stomach, was found by him, accordingly, not to prevent vomiting; whereas the division of the phrenic nerves, which supply the diaphragm, greatly impedes it.

But Dr. Haighton, one of those who have experimented on the subject, declares that the division of the par vagum did prevent vomiting in two experiments which he made. (*Memoirs of the Lond. Med. Society,* vol. ii.) Dr. Haighton observed the peristaltic action of the stomach to grow gradually fainter as sickness continued, and at length to be inverted, although alone insufficient to effect vomiting; and he concluded that vomiting resulted from the operation of the stomach on the one hand and of the abdominal muscles and diaphragm on the other. He remarked that a quantity of air was swallowed previously to the discharge, and the stomach is thus distended and brought more under the influence of the diaphragm and abdominal muscles.

"In vomiting, the muscles of the cavity of the abdomen act, in which is to be included the diaphragm; so that the capacity of the abdomen is lessened, and the action of the diaphragm rather raises the ribs, and there is also an attempt to raise them by their proper muscles, to make a kind of vacuum in the thorax, that the œsophagus may be rather opened than shut, while the glottis is shut so as to let no air into the lungs. The muscles of the throat and fauces act to dilate the fauces, which is easily felt by the hand, making there a vacuum, or what is commonly called a suction." J. Hunter, *Observations on certain Parts of the Animal Economy.*

It is generally accompanied by more or less of a peculiar sensation in the stomach, called nausea. This frequently exists alone, and sometimes in a high degree; but where it increases to a certain amount, it usually ends in vomiting. During nausea the pulse is small, the temperature low, the face pale, and the head giddy, and a large quantity of fluid is secreted in the mouth and fauces. It is excited by disgust, certain articles, pain, sympathy of the stomach with other organs not in health, by general derangement or disease of the stomach, by turning round, swinging, or the motion of a ship, and from the latter cause takes its name,—*ναῦς* (a ship).

The stomach has been called the grand centre of sympathy. Its sympathies are great, but there is no reason for considering it the *centre* of sympathy. Blows upon the head or testicle, and diseases of the kidney and uterus, nay, the mere pregnant state of the latter, severe pain in any part, or a disgusting sight, will often cause vomiting. Any depressing passion deranges the stomach, but anxiety is a common source of stomach complaints, although the stomach generally bears the whole blame, and is in vain drugged and dieted, or want of exercise or great mental occupation is regarded as the cause, while the anxiety is overlooked. Pleasurable mental exertion, " constant occupation without care," must be very excessive to injure the stomach.

The stomach itself, except as far as its inner surface is very extensive and sensible and therefore highly adapted for the influence of ingesta, appears, on the whole, to affect other organs, by mere sympathy, far less than it is influenced by them. The immediate debility and breathlessness occasioned by a blow on the stomach is, however, well known. I saw a person gradually sink, and die at the end of a few days from this cause, and nothing was detected after death.

The removal of a piece of the par vagum, or the destruction of that part of the brain with which it is connected, or of a considerable part of the spinal marrow, puts a stop, not to the muscular action of the stomach, or to its circulation, but to the secretion of gastric juice and to digestion, according to Le Gallois, *Sur le Principe de la Vie*, and many former writers; and Dr. Philip, who is confirmed by several others, declares that the removal of a portion of the nerve impairs digestion much more than mere division, and that the application of galvanism to the stomach restores digestion; and MM. Leuret and Lassaigne declare, that after the division of the par vagum, and even the removal of six inches of each nerve, digestion proceeds as before, the only effect being the paralysis of the sphincter of the cardia. I should remark, that Mr. Brodie and Dr. Magendie found even digestion uninfluenced, if the division was made, not in the neck, but close to the stomach. *Phil. Trans.* 1814. *Précis Elémentaire*, t. ii. p. 103.

CHAP. IV.

OF THE PANCREATIC JUICE.

"THE chyme, after passing the pylorus, undergoes new and considerable changes in the duodenum[a], a short but very remarkable portion of the intestine, before the nutrient chyle is separated. To this end, there are poured upon it various secreted fluids, the most important of which are the bile and pancreatic juice.

"Of these we shall treat separately, beginning with the pancreatic fluid, because it is closely allied both in nature and function to the saliva and gastric juice already mentioned.

"Although it is with difficulty procured pure from living and healthy animals, all observations made in regard to it establish its close resemblance to the saliva. At the present day, it would scarcely be worth while to mention the erroneous hypotheses of Franc. Sylvius[b] and his followers — Regn. De Graaf[c], Flor. Schuyl[d], and others, respecting its supposed acrimony, long since ably refuted by the celebrated Pechlin[e], Swammerdam[f], and Brunner[g], unless they afforded a salutary admonition, how fatal the practice of medicine may become, if not founded on sound physiology.

"The source of this fluid is similar to that of the saliva. It is the *pancreas*[h], — by much the largest conglomerate gland in the system, excepting the breasts," being about three times heavier than all the salivary glands together[i], "and extremely analogous to the

[a] "Laur. Claussen, *De Intestini Duodeni situ et nexu.* Lips. 1757. 4to. Reprinted in Sandifort's *Thes.* vol. iii.

And his *Tabulæ Intestini Duodeni.* LB. 1780. 4to."

[b] "*De Chyli a fæcibus alvinis secretione.* LB. 1659. 4to."

[c] "*De succi Pancreatici Natura et Usu.* ib. 1664. 12mo."

[d] "*Pro Veteri Medicina.* ib. 1670. 12mo."

[e] "*De Purgantium Medicamentorum Facultatibus.* ib. 1672. 8vo."

[f] "*Observationum Anatomic. Collegii privati Amstelodamens.* P. ii. *in quibus præcipue de piscium pancreate ejusque succo agitur.* Amst. 1673. 12mo."

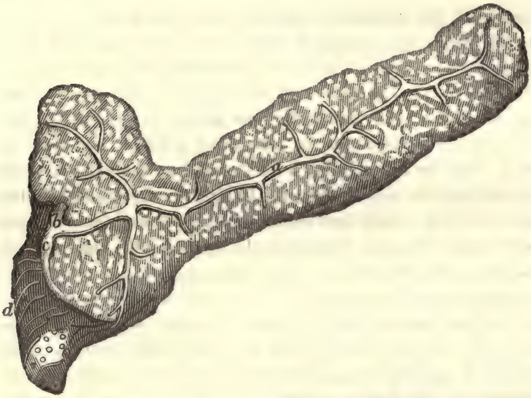
[g] "*Experimenta nova circa pancreas.* Amst. 1683. 8vo."

[h] "Santorini, *Tab. Post.* xiii. fig. 1."

[i] Marherr, *Prælectiones in* Her. Boerhaave, *Instit. Med.* t. i. § ci.

salivary glands in every part of its structure, even in the circumstance of its excretory ducts arising by very minute radicles and uniting into one common duct, which is denominated, from its discoverer Wirsüngian.

"This duct penetrates the tunics of the duodenum, and supplies the cavity of this intestine with a constant stillicidium of pancreatic juice."[k]



Pancreas. *a*, pancreatic duct: *b*, choledochus : *c*, junction of the two and their termination in the duodenum : *d*, a portion of the duodenum divided.

The quantity of the pancreatic juice cannot be accurately ascertained. It is, no doubt, produced copiously during chylification, and cannot be expected to flow readily at other times, or naturally under the torments of an experiment.

"The excretion of this fluid is augmented by the same causes which affect that of the saliva,—pressure and stimulus.

"By the former it is emulged, whenever the stomach lies in a state of repletion upon the pancreas.

"The stimuli are the fresh and crude chyme entering the duodenum, and the bile flowing through the opening common to it and the pancreatic fluid."

The use of the pancreatic juice is unknown, but Tiedemann and Gmelin conceive that it animalises the unazotised principles of vegetable food. The organ is certainly much larger proportionately in herbivorous than in carnivorous animals. They assign the same purpose to the saliva.

[k] Mr. Kiernan states, that in some subjects the internal surface of the duct is studded with mucous follicles; whereas none are ever found in the ducts of the parotid or submaxillary glands. *Phil. Trans.* 1833. p. 728.

The pancreatic juice, at least in the sheep, according to them, has twice as much solid contents as the saliva, and conversely a large quantity of albumen and fatty matter with a small quantity of salivary matter and mucus; is neutral, or has only a little alkaline carbonate, and no sulpho-cyanic acid.

The pancreas exists in all the mammalia, birds, reptiles, and fishes.

Brunner, about 150 years ago, removed almost the whole pancreas from dogs, and tied and cut away portions of the duct; and they lived apparently as well as before. From one he was not contented with removing the spleen at one time and the pancreas at another, after which the poor animal *pancratice valebat;* but, to render it celebrated for experiments, he on a third occasion laid bare the intestines and wounded them for an inch and a half, sewed up the wound, made a suture in the abdominal parietes so badly that the intestines were found hanging out on the ground one morning, purple and cold, and then allowed the animal to lick the wound into healing. He also performed the operation for aneurysm in the artery of its hind leg, and paracentesis of its chest, injecting a quantity of milk into the pleura and pumping it out again. This even was not enough for the gentle Brunner; he gave the dog such a dose of opium, when it had recovered from the operation on the spleen, that it was seized with tetanus. But this also it got the better of, and lived upwards of three pleasant months with its master, "gratus mihi fuit hospes," after all these indulgences, and was at last lost in a crowd; stolen, no doubt, because "celebris ab experimentorum multitudinem, — vivum philosophiæ experimentalis exemplum, et splene mutilus, variis cicatricibus notabilis." Brunner offered any money for it again, but to no purpose. (p. 6. 13.)

CHAP. V.

THE BILE.

"THE bile is secreted by the *liver*[a]—the most ponderous and the largest of all the viscera, especially in the fœtus[b], in which its size is inversely as the age. The high importance of this organ is manifested, both by its immense supply of blood-vessels and their extraordinary distribution, as well as by its general existence, for it is not less common to all red-blooded animals than the heart itself.[c] It exists also in invertebral animals with colourless blood, wherever a heart and blood-vessels are present.

"The substance of the liver is peculiar, easily distinguished at first sight from that of other viscera, of well-known colour and delicate texture[d], supplied with numerous nerves[e], lymphatics (most remarkable on the surface)[f], biliferous ducts, and, what

[a] "Eustachius, tab. xi. fig. 3, 4.
Ruysch, *Thes. Anat.* ix. tab. iv.
Santorini, *Tab. Posth.* xi."

[b] "J. Bleuland, *Icon hepatis fœtus octimestris.* Traj. ad Rhen. 1789. 4to.
F. L. D. Ebeling, *De Pulmonum cum hepate antagonismo.* Gott. 1806. 8vo."

[c] "See Nic. Mulder's *Diss. de functione hepatis, in Disquisitione zootomica illius visceris nixa.* Lugd. Bat. 1818. 8vo."

[d] "In which, however, Autenreith discovers two substances, the one medullary and the other cortical. *Archiv. für die Physiol.* t. vii. p. 299.
Consult also J. M. Mappe's Dissertation, *De penitiori hepatis humani structura,* Tub. 1817. 8vo."

[e] "Walter, tab. iv."

[f] "Maur. v. Reverhorst, *De motu bilis circulari ejusque morbis,* tab. i. fig. 1, 2.
Ruysch, *Ep. Problemat.* v. tab. vi.
Werner and Feller, *Descriptio vasor. lacteor. atque lymphaticor.* Fascic. i. tab. iii. et iv.; although Fr. Aug. Walter finds fault with these plates, *Annot. Academic.* p. 191. sq.
Mascagni, tab. xvii. xviii."

these ducts arise from, blood-vessels[g], which are both very numerous and in some instances very large, but of different descriptions, as we shall state particularly.

" The first blood-vessel to be noticed is the *vena portarum* (or *portæ*), dissimilar from other veins, both in its nature and course. Its trunk is formed from the combination of most of the visceral veins belonging to the abdomen, is supported by a cellular sheath called the capsule of Glisson[h], and, on entering the liver, is divided into branches which are subdivided more and more as they penetrate into the substance of the organ, till they become extremely minute, and spread over every part. Hence Galen compared this system to a tree whose roots were dispersed in the abdomen, and its branches fixed in the liver.[i]

" The other kind of blood-vessels belonging to the liver, are branches of the *hepatic artery*, which arises from the cœliac, is much inferior to the vena portæ in size, and in the number of its divisions, but spreads by very minute ramifications throughout the substance of the organ.

" The extreme divisions of these two vessels terminate in true veins, which unite into large venous trunks running to the *vena cava inferior*.

" These extreme divisions are inconceivably minute and collected into very small glomerules[k], which deceived Malpighi into the belief that they were glandular acini, hexagonal, hollow, and secretory.[l]

" From these glomerules arise the *pori biliarii*—very delicate ducts, secreting the bile from the blood, and discharging it from the liver through the common hepatic duct, which is formed from their union."

Such is the account of the anatomy of the liver, given by most writers as well as Blumenbach. But Dr. Müller, Professor at Bonn,[m] declares that he has discovered all glands, and the

[g] " See Haller, *Icones Anat.* Fascic. ii. tab. ii."

[h] " Glisson, *Anatomia Hepatis*, p. 305. sq. 1659."

[i] " *De Venarum Arteriarumque dissectione*, p. 109. Opera. Basil. 1562. Cl. i."

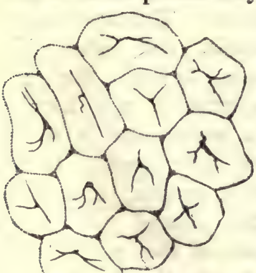
[k] " Nest. Maximeow. Ambodick, *De Hepate.* Argent. 1775. 4to."

[l] " *De viscerum structura*, p. 11. Lond. 1669."

[m] *De Glandularum secernentium Structura penitiori, earumque prima Formatione in Homine atque in Animalibus.* Lipsiæ. 1830.

liver among the rest, to be mere ducts, beginning from blind extremities, and having blood-vessels ramifying on their parietes. The *biliferous ducts*, therefore, are not continuous, as Blumenbach says, with blood-vessels; and Haller remarks, that no one ever discovered such a continuation: but their fluids must be poured into them from their inner surface, as fluids are secreted into canals lined by mucous membrane.

Mr. Kiernan has recently published a most elaborate and original paper upon the structure of the liver, and states, — That the extreme subdivisions of the *hepatic artery* all terminate in, or become, veins that run into the branches of the vena portæ; so that this vein originates not only from the veins of the other abdominal viscera, but also in the liver itself, as Ferrein pointed out a century ago, and the artery has no termination in either biliferous ducts or hepatic veins, and is destined for nutrition, not for the secretion of bile. — That the subdivisions of the *vena portæ* (except, I presume, those which become secreting vessels in the coats of the minutest biliferous ducts, and pour forth fluid from their extremities upon the inner surface of those ducts, unless indeed the fluid pass through pores in their sides,) all terminate in, or become, the hepatic veins: — That the minutest biliferous ducts, the subdivisions of the vena portæ, and the hepatic veins, are conglomerated into minute masses or lobules, which Wepfer first discovered in the pig, surrounded, except at their base, with a capsule of cellular membrane, that is a prolongation of Glisson's capsule and the proper capsule of the liver, and supplied with minute arteries, and probably nerves and absorbents; when there is much cellular membrane in the capsule, the lobules not being close together, but touching each other by two or three points only, and being more or less circular or oval; when the reverse is the case, being closely compacted, and therefore angular: — That the branches of the vena portæ, after running between the lobules, and covering them (except at their bases) and freely anastomosing around them, so as to form a continued plexus throughout the liver, enter the lobules most minutely subdivided, and become hepatic veins, which unite into one large vessel in each process of every lobule, and then these large vessels run into one which passes



down the centre of the lobule, and goes out at the base, so as to look like a stalk to the lobule. The veins formed from

these run between the bases of the lobules and anastomose, and are called sublobular, to distinguish them from the hepatic veins within, which are called intralobular and do not anastomose, and from the portal branches without, which run between the other parts of the surface of the lobules, or rather in the capsules of the lobules, and are called interlobular and anastomose so freely.

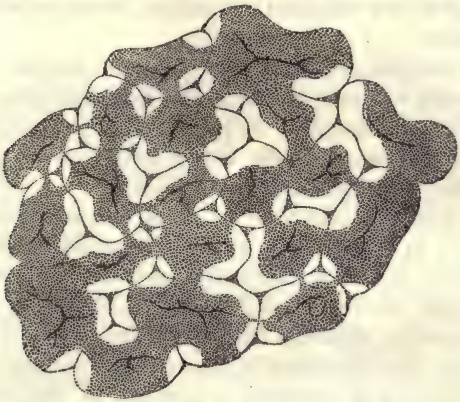
The lobules are very sparingly supplied with arteries, while the biliferous ducts possess outside the lobules an abundance of them.

The minutest biliferous tubes form a reticulated plexus in each lobule, and unite into branches which leave it. These lobular biliary plexuses have much the appearance of cells, and deceived some into the belief of cells which give origin to ducts; and these Malpighi and others erroneously termed acini.

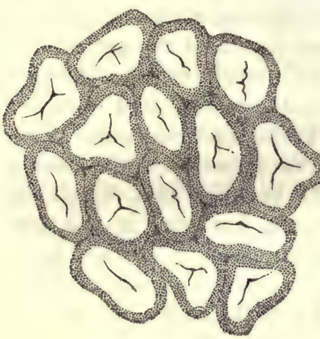
As the liver so abounds in venous blood, it is very liable to congestion; and any impediment to the exit of the blood from the hepatic veins, as in diseases of the chest, will cause it to accumulate in the large branches, then in the sublobular, the central hepatic vein of each lobule, the twigs which run to it, and at length in the central part of the lobular portal plexuses. If the congestion is not greater, the central portion of the

lobules becomes red, and the outer portion retains its usual yellowish colour. This appearance made Ferrein, and after him many others, believe that two substances exist in the liver, a red and a white; and it is the usual state after death. If the congestion is greater, it extends beyond the central portion of the plexuses of the portal veins in the lobules, even to the portal branches in the fissures, and the redness reaches the edge of the lobules for the greater

part — except where the lobules are not quite in contact with each other; and the liver in this state is called a nutmeg liver.



When still greater, the whole of each lobule is red.



Congestion beginning in the vena portæ is very rare, and the outer portion of the lobules is then red, while the central, in which the hepatic veins lie, remains pale.[n]

"It has been disputed whether the bile is produced from arterial or venous blood.

"The former opinion[o] is countenanced by the analogy of the other secretions which depend upon arterial blood; nevertheless more accurate investigation proves that the greater part, if not the whole, of the biliary secretion is venous.

"With respect to arguments derived from analogy, the vena portæ, resembling arteries in its distribution, may likewise bear a resemblance to them in function. Besides, the liver is analogous

[n] *Phil. Trans.* 1833.

[o] "This has found an advocate in Rich. Powel, *On the Bile and its Diseases.* Lond. 1801. 8vo."

to the lungs, in which the great pulmonary vessels are intended for their function, and the bronchial arteries for their nourishment; and, if we are not greatly mistaken, the use of the hepatic artery is similar."

M. Simon informs us, that, after tying the hepatic artery in pigeons, the bile was secreted as usual; but after tying the vena portæ, none was produced.[p] A. Kaau found water injected into either the vena portæ or hepatic artery exude on the surface of the liver[q]; but this might be mere imbibition.

From the great abundance of twigs of the vena portæ which are distributed in the lobules, among the original biliferous or secreting ducts, and the extremely small number of arteries which enter the lobules, though they run plentifully upon the larger or excreting biliferous ducts, Mr. Kiernan infers that the bile is secreted from the blood of the vena portæ alone.

Two instances have occurred in London, of the vena portæ running, not to the liver, but immediately to the vena cava inferior. One is described by Mr. Abernethy[r], and the other is mentioned by Mr. Lawrence.[s] Mr. Kiernan has examined the preparation made from Mr. Abernethy's case, and found that the branches of the umbilical vein were open, and communicated with the hepatic artery, the blood of which, having become venous in the capillaries, must have found its way for secretion to the lobules by means of the ramifications of the umbilical vein, which was in truth, as it always is, the vena portæ, but arose in this case from the extremities of the hepatic artery alone, and not, as in ordinary cases, from them and the extremities of the arteries of the other abdominal viscera, by means of their veins, which unite to form what is termed properly the vena portæ.

In the mollusca, there is certainly no vena portæ, and the liver receives its blood from the aorta.

" The *bile* flows slowly, but constantly, along the hepatic duct. The greater portion runs constantly through the ductus communis choledochus into the duodenum, but some passes from the hepatic into the *cystic duct*, and is received by the gall-bladder, where it

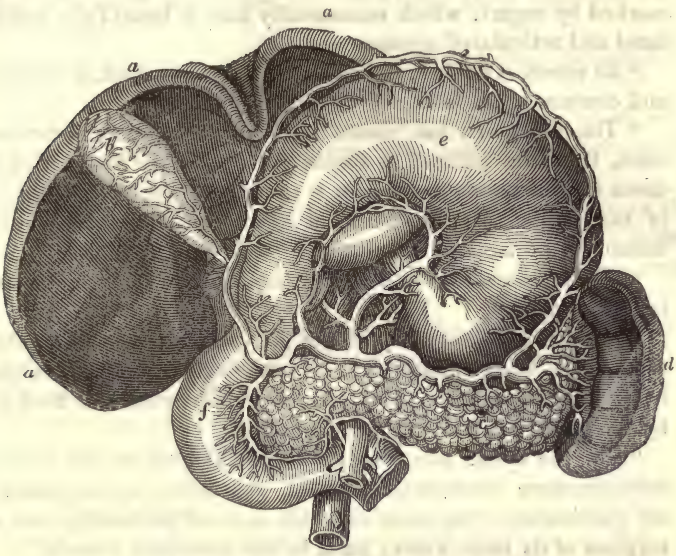
[p] *Edinburgh Journal of Medical Science,* No. i. p. 229. This effect of tying the vena portæ was long ago observed. See Sömmerring, *De C. H. Fabrica,* t. vi. p. 182.

[q] *Perspiratio dicta Hippocrat.* 563.

[r] *Phil. Trans* vol. lxxxiii.

[s] *Medico-Chirurgic. Trans.* vol. v. p. 174

remains for a short period, and acquires the name of *cystic bile*.[t]



The liver, gall-bladder, and stomach, raised.

a a a, liver; *b*, gall-bladder; *c*, pancreas; *d*, spleen; *e*, stomach; *f*, duodenum. See also the cut at the end of Chap. II.

" The *gall-bladder* is an oblong sac, nearly pyriform, adheres to the concave surface of the liver, and consists of three coats :—

" An *exterior*, not completely covering it, derived from the peritonæum.

" A *middle*, called nervous, and, as in the stomach, intestines, and urinary bladder, the source of its firmness and tone.

" An *interior*[u], which may be, in some measure, compared to

[t] " In the ox and other brutes there are peculiar *hepato-cystic* ducts, which convey the bile directly from the liver to the gall-bladder.

See *Observat. Anatom. Collegii privati Amstelodamens.* P. i. Ams. 1667. 12mo. p. 16. fig. 7.

Also Perrault, *Essais de Physique*, t. i. p. 339. tab. ii.

Some have inconsiderately allowed them also in the human subject: v. c. De Haen *Ratio medendi contin.* P. ii. p. 46. sq. tab. x. fig. 1.

Also Pitschel, *Anat. und chirurg. Anmerk.* Dresd. 1784. 8vo. tab. i.

Consult more at large, R. Forsten, *Quæstiones selectæ physiologicæ.* Lugd. Batav. 1774. 4to. p. 22."

[u] " Ruysch, *Epist. problem. quinta.* Tab. v. fig. 3."

the inner coat of the stomach, as it contains a network of innumerable blood-vessels, abounds in mucous glands[x], and is marked by rugæ[y], which occasionally have a beautifully cancellated and reticulated appearance.

" Its cervix is conical, terminates in the cystic duct, is tortuous, and contains a few falciform valves.[z]

" The bile which has passed into the gall-bladder is retained until, from the reclined or supine posture of the body, it flows down from it spontaneously, or is squeezed[a] out by the pressure of the neighbouring jejunum, or ileum, or of the colon when distended by fæces.

" The presence of stimuli in the duodenum may derive the bile in that direction.

" The great contractility of the gall-bladder, proved by experiments on living animals, and by pathological phenomena, probably assists the discharge of bile, especially when this fluid has, by retention, become very stimulating.

" For the cystic bile, though very analogous to the hepatic, becomes more concentrated, viscid, and bitter, by stagnation in the gall-bladder; the cause of which is, in all probability, the absorption of its more watery parts by the lymphatic vessels."[b]

Many animals have no gall-bladder; *v. c.* the horse, goat, &c. All the carnivorous among the mammalia possess it, and all reptiles, most of which also are carnivorous; while those of the class mammalia that are destitute of it, are, with the exception of the porpoise and dolphin, vegetable feeders. Hence, Cuvier thinks that it is intended as a reservoir of bile where the animal is subject to long fasting from the uncertain supply of food. The gall-bladder is sometimes absent in the human subject. I have read of six instances of this.[c]

[x] " Vicq-d'Azyr, *Œuvres*, t. v. p. 343."

[y] " Casp. Fr. Wolff, *Act. Acad. Scient. Petropol.* 1779. P. ii."

[z] " Caldesi, *Osservaz. intorno alle Tartarughe.* Tab. ii. fig. 10.
But especially Wolff, lately commended, l. c. P. i. tab. vi.
Also Fr. Aug. Walter, l. c. tab. i."

[a] " Caldani, *Institut. Physiolog.* p. 364. sq. Patav. 1778. 8vo."

[b] " See Reverhorst, l. c. tab. ii. fig. 3.
Ruysch, l. c. tab. v. fig. 4.
Werner and Feller, l. c. tab. ii. fig. 5.
Mascagni, tab. xviii."

[c] *Phil. Trans.* 1749. The subject was a woman sixty years of age. Also l. c. 1813. *Transact. of the Coll. of Phys.* vol. vi. Mr. Cook's edition of Morgagni, *Gazette de France,* 1826; and *Journal Hebdomadaire,* referred to in the *London Medical Gazette,* 1829.

"Our attention must now be turned to the bile itself—a very important fluid, respecting the nature and use of which there has been more controversy for these forty years than about any other fluid.

"The cystic bile, being more perfect and better calculated for examination, will supply our observations.

"Bile taken from a fresh adult subject is rather viscid, of a brownish green colour[d], inodorous, and, if compared with that of brutes, scarcely bitter."

Berzelius[e] stated, that bile contains alkali and salts in the same proportion as the blood, and that no resin exists in it, but "a peculiar matter, of a bitter and afterwards somewhat sweet taste, which possesses characters in common with the fibrin, the colouring matter, and the albumen of the blood." This forms, with an excess of acid, a perfectly resinous precipitate. What was considered albumen in the bile, Berzelius regarded as the mucus of the gall-bladder.

Bile contained, according to him, of

Water - - - - - -	907·4
Biliary matter - - - -	80·0
Mucus of the gall-bladder dissolved in the bile -	3·0
Alkalies and salts common to all secreted fluids -	9·6
	1000·0[f]

Of the weight of alkalies and salts, more than one half was pure soda.

Tiedemann and Gmelin make the bile of the ox to consist of 91·51 water, with 7·30 proximate principles, and 1·19 salts. The biliary matter, or picromel, they find a compound of resin and a sweet crystallisable substance, which, together with another, termed by them biliary asparagin, renders the resin soluble in water. They discover also ozmazome[g], and a new acid — the cholic, also cholesterin, gliadine, casein, the oleic, acetic, phosphoric, sulphuric, and muriatic acids, and colouring matter. The

[d] "On the variety of colour in the bile, consult Bordenave, *Analyse de la Bile*, in the *Mém. Présentés*, &c. t. vii. p. 611. 617."

[e] *Animal Chemistry*, p. 65.

[f] *Med. Chirurg. Trans.* vol. iii. p. 241.

[g] A substance produced, like gelatin, by boiling, and obtained from muscle, serum, or even mushrooms; and, according to M. Raspail, it is a mere impure combination of albumen and acetic acid.

soda, they say, is not pure, but a bicarbonate, and mixed with a little potass.

M. Raspail remarks, that we may defy a chemist to either verify the analysis of Berzelius or Tiedemann and Gmelin, or not to increase the number of indeterminate substances which figure in them, and this the more minute he attempts to be. He considers, with M. Cadet, that bile is essentially a soap, with soda for its base, and mixed with sugar of milk; and that the other substances are all accessary. Thus, the bile of the pig is a soap with scarcely any albumen or picromel; that of birds contains a large quantity of albumen, and its picromel has no sugar; that of fish has no resin, and its picromel is very sweet, and slightly acrid; human bile has no picromel, and has the less resin the more fatty the liver. As to picromel, he regards it as a substance to be made at pleasure by mixing resin, sugar, and an alkali or acid.[h]

Fourcroy first explained the chemical operation of the bile in chylification.[i] According to Dr. Prout, during the precipitation of the chyle and the decomposition of the bile, a gaseous product is usually evolved, the mass becomes neutral, and traces *of an albuminous principle* commence, strongest at a certain distance from the pylorus,—below the point at which the bile enters the intestine, and gradually fainter in each direction. On mixing bile with chyme out of the body, a distinct precipitation takes place, and the mixture becomes neutral; but the formation of an albuminous principle is doubtful, probably from the want of the pancreatic fluid.[k]

The bitter and bilious yellow matters pass off with the fæces, while the alkali (soda) of the bile probably combines with the acid, and contributes to the formation of the chyle. The sugar disappears. The loss of the alkali, which preserved the biliary yellow, bitter, resinous matters in solution, causes the separation of the latter; and Dr. Prout found their distinctive qualities the more evident, the further from the intestine they were examined.

It is no longer wonderful that in jaundice, so intense that no bile is seen in the fæces, and, according to Dr. Fordyce, even in artificial obstruction of the choledochus by ligature, nutrition continues, though, no doubt, less perfectly than in health. For

[h] l. c. p. 451. sqq.

[i] *Systême des Connoissances Chimiques*, t. x. p. 49.

[k] Dr. Prout, Thomson's *Annals of Philosophy*, 1819. p. 273.

Tiedemann and Gmelin, after tying the biliary duct, which proved on dissection to have continued impervious [1], found the thoracic duct still containing an abundance of matter, yellowish, indeed, from the jaundice, but coagulating, and its coagulum becoming red, precisely like chyle; the small intestines had the soft flakes usually considered chyle, but thought mucus by them, and both large and small intestines contained nearly all the principles, except those of the bile, seen in sound animals; but the contents of the large intestines were exceedingly offensive. In the less satisfactory experiments of MM. Leuret and Lassaigne, the thoracic duct was still full of chyle.

Although the bile is seen, by experimenting upon the contents of the duodenum, to cause a precipitation (Tiedemann and Gmelin deny it, but Dr. Prout has almost constantly seen it), the chyle

In the year 1817, Dr. James Blundell tied the choledochus several times in the dog and rabbit, and has ever since mentioned the results in his physiological lectures. Generally the animal died of peritoneal inflammation, the bile forcing its way into the cavity among the viscera, when the ligature had produced ulceration; but when the animal did not die, the jaundice disappeared after a time, and the animal was nourished as before: the bile had found some outlet. On opening the animals, about a fortnight after the experiment, he discovered that fibrin had been effused round the tied portion of the duct, so as to re-establish the canal, and the ligatures had disappeared. Dr. Blundell's well-known accuracy renders all confirmation unnecessary, but I may mention, that Mr. Brodie and others have since made the same experiment with the same results.

Dr. Blundell has on record the cases of two infants, four or five months old in whom the hepatic ducts terminated blindly; so that no bile entered the intestines, and the stools were white, like spermaceti, and the skin jaundiced. But the infants grew rapidly, and throve tolerably notwithstanding. He therefore saw that nourishment could be accomplished without the mixture of bile and chyme. Of these cases, one was examined by Mr. Luke, of the London Hospital, the other by Mr. Gaunt, of Falcon Square.

Dr. Blundell has for many years been in the habit of displaying the precipitating agency of the bile upon the chyme, by varying the mode of admixture: 1. By working chyme and bile together, when the white chyle appears in the mass, like veins in marble: 2. By enclosing chyme in black silk, and wetting a part of the external surface of this printer's ball, as it may be called, with bile; when, on rendering it tense, the liquid portion of the chyme oozes through the texture, and renders it generally blacker, but whitens it conspicuously in those spots where it meets with bile: 3. By filtering the chyme repeatedly, and then dipping into the thin strained fluid a rod with a drop of bile at its extremity, white chyle appears at the point of contact.

He found the same results in the curious hybrid experiment, of employing the bile of a dog, and the chyme of a rabbit.

may thus be separated without it; but probably, Dr. Prout conceives, in less quantity and perfection.

The neutralising effect of the bile, he informs me, is evident on laying a piece of litmus paper through the pylorus, when the portion in the stomach becomes red, and that in the intestines is unaffected, or even shows alkaline agency.

The further down the intestinal contents are examined, the more do all traces of albuminous matters disappear, as well as of all the highly azotised[m] principles of the pancreatic juice, these being supposed to convert the unazotised principles of the vegetable food into albumen: in man and carnivorous brutes no traces of either are discoverable so low down as the cæcum.

Dr. Prout remarks, that "admitting that the decomposition of the salt of the blood is owing to the immediate agency of galvanism, we have in the principal digestive organs a kind of galvanic apparatus, of which the mucous membrane of the stomach, and perhaps that of the intestinal canal generally, may be considered as the acid or positive pole; while the hepatic system may, on the same view, be considered as the alkaline or negative pole."[n]

The hypothesis, that one great use of the liver was, like that of the lungs, to remove carbon from the system, with this difference, that the alteration of the capacity of the air caused a reception of caloric into the blood, in the case of the lungs, while the hepatic excretion takes place without introduction of caloric,— was, I recollect, a great favourite with me when a student, principally from the facts that a supply of venous blood—blood which has been used by the system—runs to both liver and lungs, and to no other organs; that the higher the temperature, the less carbon passed off by the lungs (less caloric being demanded by the body), and the more abundant, or more acrid, became the bile; so that bilious diseases are most prevalent in hot seasons and climates. The Heidelberg Professors have adduced many arguments to the same effect. In the fœtus, for whose temperature the mother's heat must be sufficient, the lungs perform no function, but the liver is of great size, and bile is secreted abundantly, so that the meconium accumulates considerably during the latter months of

[m] In examining the blood, we shall find that M. Raspail considers nitrogen to exist in animal and vegetable substances, combined with hydrogen as ammonia.

[n] *Bridgewater Treatise*, 496. sq.

pregnancy. We shall see, indeed, that at the very time the functions of the lungs suddenly begin at birth, the liver suddenly loses much of its supply of blood. Warm-blooded animals with large lungs, living in the air, have the liver proportionally smaller than those which live partly in water: in cold-blooded animals, and reptiles, which have lungs with such large cells as but slightly to decarbonise the blood; in fish, which get rid of carbon but slowly by the gills; and in the mollusca, which decarbonise still more slowly by gills or lungs, — the liver is proportionally large. More blood flows to the liver, accordingly as the lungs are less active organs. In the mammalia and birds it receives the blood of only the stomach, intestines, spleen, and pancreas; but in the cold-blooded, of many other parts; in the tortoise, of the hind legs, pelvis, tail, and vena azygos; in serpents, of the right renal, and all the intercostal veins; in fish, of the renal veins, the tail, and genitals. They assert, that in pneumonia and phthisis more bile is secreted, and in the *blue disease*, and other affections of the heart, that the liver is enlarged. The constituents of the bile contain a large quantity of carbon, which is chiefly in union with hydrogen, and under the form of resin or fatty matter, and resin is most abundant in the bile of herbivorous animals, whose food contains a very large proportion of carbon and hydrogen. In the lungs the carbon may be said to be burnt, whence animal heat; in the abdomen it passes off still combustible.

CHAP. VI.

OF THE FUNCTION OF THE SPLEEN.

"The *Spleen*[a] lies to the left of the liver, with which it has considerable vascular communications; by its oblong figure[b], it accommodates itself, as it were, to the contiguous viscera, but is liable to great varieties in point of form, number, &c.[c]

"Its colour is livid, its texture peculiar, soft, easily lacerated, and therefore surrounded by two membranes, the interior of which is proper to the spleen, and the exterior derived from the omentum.

"The situation and size of the spleen are no less various than its figure, and depend upon the degree of the stomach's repletion; for, when the stomach is empty and lax, the spleen is turgid; when the stomach is full, the spleen, being compressed, is emptied.

"It undergoes a continual, but gentle and equable, motion, dependent upon respiration, under the chief instrument of which—the diaphragm, it is immediately situated.

"Its texture was formerly supposed to be cellular, and compared to the corpora cavernosa of the penis."

Winslow says, "there are no venous ramifications in the ox and sheep. Having entered into the large end of the organ, the vein

[a] "Ch. Drelincourt, the younger, has carefully collected and concisely related whatever was known up to his time, respecting the spleen; *De lienosis,* at the end of his father's Opuscula. Boerhaave's edition, p. 710. sq.

Consult, also, Chr. Lud. Roloff, *De fabrica et functione lienis.* Frf. ad Viadr. 1750. 4to.

But among more recent writers, see L. J. P. Assolant, *Recherches sur la Rate,* Par. 10. 8vo.

C. F. Heussinger, *über den Bau und die Verrichtung der Milz.* Isen. 1817. 8vo.

And Chr. Hellw. Schmidt, *Commentatio* (which gained the royal prize) *de pathologia lienis,* &c. Gott. 1816. 4to."

[b] "Walter, tab. iii. G.
Mascagni, tab. xiv. P."

[c] "See Sandifort, *Natuur en genees-kundige Bibl.* vol. ii. p. 345. sq."

goes about an inch and a half; then, instead of being like other veins, it becomes perforated on all sides. The beginning of this canal has still a portion of the coats of the vein, but the form of the whole canal is gradually effaced, so that nothing remains but grooves in the cellular structure."[d]

" This opinion was proved," says Blumenbach, " to be erroneous by more careful examination of the human spleen [e], which consists entirely of blood-vessels, of enormous size in comparison with the bulk of the organ: they are, in fact, proportionably more considerable than in any other part of the body."

But Dr. Andral affirms, that " by repeated washing, the spleen is shown to consist of an infinite number of cells, which communicate on the one hand together, and on the other directly with the splenic veins. The latter, when the inner surface of the large subdivisions of the splenic veins are examined, appear to have a great number of perforations, through which a probe passes directly into the cells of the organ. The farther the subdivisions of the vein examined are from the trunk, the larger are these perforations; and still further on, the coats of the vein are not a continued surface, but are split into filaments, which do not differ from those forming the cells, and are continuous with them." " The cells are produced in the following manner: from the inner surface of the investing membrane of the spleen, a great number of filaments, fibrous like itself, are detached, some of which grow broad, and resemble flakes, and the latter chiefly seem intended to support the divisions of the artery. In interlacing each other, these filaments leave spaces, which are in fact the cells of the spleen, and they terminate by insertion into the walls of the veins, becoming continuous with the filaments into which the veins are ultimately reduced." These facts are readily ascertained in the spleen of the horse; but may also be verified in the human spleen.[f]

" The experiments of Wintringham demonstrate the great tenuity and strength of the coats of the splenic artery. It is divided into an infinite number of twigs, the terminations of which resemble pulpy penicilli and give rise to the splenic veins, which gradually unite into large, loose, and easily dilatable, trunks."

Andral says, that the splenic artery, almost as soon as it enters

[d] *Exposition Anatomique du Corps Humain*, t. iv. p. 136. sqq.

[e] " See Lobstein's Dissertation, *Nonnulla de Liene sistens*. Argent. 1773. 4to."

[f] *Précis d'Anatomie Pathologique*, t. ii. P. i. p. 416. sqq.

the spleen, rapidly diminishes, and subdivides into twigs, which cannot be traced, and appear to be distributed on the sides of the cells. The cellular structure of the spleen enables us to inflate it by the veins. Winslow, a century since, did this; and when inflated, it has a great resemblance to the lungs with large cells of certain reptiles.

The spleen of brutes has been removed, from the most remote period, without effect.[g]

At least twenty hypotheses respecting the use of the spleen have been advanced. In some, it has been regarded as a diverticulum to the blood.[h]

Above a century ago, Dr. Stukely[i], considering the spleen to consist entirely of complications and inosculations of arteries, veins and cells, nerves, and (as Malpighi asserted) "a muscular net-work of fibrillæ," supposed that it contracted and propelled its blood through the splenic vessels into those of the stomach, when this organ required a larger supply during digestion. He maintained, likewise, that it accelerated the motion of the blood in the mesenteric veins when the circulation in the vena portæ was sluggish, and that it answered various other purposes. The whole is an hypothesis now forgotten.

Some have thought it a diverticulum for the blood whenever this fluid is obstructed in any part of the body, as in the cold stage of fever, great efforts, &c. To prevent too much from being thrown upon organs which might be injured, the spleen, they contend, is formed to allow an accumulation in its substance. This is ingeniously defended by Dr. Rush.[k]

Dr. Haighton (Lectures at Guy's Hospital), and Mr. Saumarez (*New System of Physiology*), have explained its operations as a diverticulum in a very different manner. When the stomach is full, the compression experienced by the spleen impedes its circulation, and the blood makes its way the more copiously into the arteries of the stomach, liver, &c. But we have no proof that the repletion of the stomach compresses the spleen materially,

[g] "J. H. Schulze, *De splene canibus exciso*. Hal. 1735. 4to."

[h] "Vinc. Malacarne, *Memorie della Soc. Italiana*, t. viii. P. 1. p. 233.
A. Moreschi, *Del vero e primario uso della milza*. Milan, 1803. 8vo."

[i] *Of the Spleen, its description and history, uses and diseases, particularly the vapors, with their remedy. Being a lecture read at the Royal College of Physicians.* By Wm. Stukely, M.D. C.M.L. and S.R.S. London, 1722. folio.

[k] Cox's *Medical Museum*, Philad. 1807.

and thus can impede its circulation: a fact, indeed, which will be mentioned presently, renders this improbable. Besides, in ruminating animals, as Blumenbach observes, it lies next the first stomach or paunch, and if compressed, must be so before digestion begins; and in proportion as the fourth stomach fills, and digestion proceeds more actively, is the distension of the paunch diminished. It varies in situation in different animals, not being always attached to the stomach. The excitement, too, which the liver must experience when chyme irritates the extremity of the ductus choledochus, and still more the provision of a gall-bladder, must render such aid from the spleen superfluous to the liver. The infinite blood-vessels and excerning orifices of the stomach cannot, likewise, but furnish sufficient gastric juice, from the mere excitement which they must experience whenever the stomach contains food. No other glands habitually excited to occasional great activity have such a diverticulum.

A third view of its influence as a diverticulum is, that it serves for receiving a great part of the venous blood of the alimentary canal during chymification, and especially during chylification. When this process is going on, there must be a great increase of blood flowing to the alimentary canal; the vena portæ, through which it all flows, can dilate to only a certain extent, and, in order to prevent such a congestion in the mesenteric veins as would retard the circulation in the organs, the spleen allows an accumulation in itself. Leuret and Lassaigne found the spleen of a dog weigh a pound and a half in two hours after the application of a ligature to the vena portæ, while it ordinarily weighs but two ounces; and observe that it has a vermilion tint when an animal is fasting, but grows turgid and of a dark purple when the chyme has passed the pylorus.

If the opinion of Erasistratus, that the spleen is useless, was a little atheistical, the notion of Paley was not much better, — that the viscera contained, and the abdomen containing, are so clumsily adapted to each other, that a pad is necessary to make them fit, just as hatters put stuffing under the leather of a hat which is made too big for the head, — "It is possible, in my opinion, that the spleen may be merely a stuffing, a soft cushion to fill up a vacuum or hollow, which, unless occupied, would leave the package loose and unsteady."[1] When I consider the stupendous

[1] *Natural Theology*, c. xi.

power and design displayed throughout nature, I instantly revolt at such an explanation as Paley's, to say nothing of its anatomical absurdity.

Sir Everard Home once fancied that the spleen is intended to receive "a great portion of our *drink* from the *cardiac* end of the stomach, so that these may pass through a short cut, hitherto unknown, from the stomach to the spleen, and thus into the mass of blood."[m] His friends having, among other experiments, passed a ligature around the pyloric extremity of the stomach of a dog, injected into this receptacle a solution of rhubarb; and, on killing the animal, some few hours afterwards, none of the absorbents of the stomach were found distended, nor could any trace of rhubarb be detected in the liver, but evident traces existed in the spleen and in the urine. When fluids had been drunk, the spleen was turgid, and exhibited cells full of a colourless liquid that were at other times collapsed and almost imperceptible,—a circumstance rendering it unlikely, I may remark in reference to Dr. Haighton's hypothesis, that the spleen is diminished in bulk by the distension of the stomach; for, first, compression, sufficient to prevent the artery from sending into it the usual quantity of blood, would prevent the entrance of fluids by any other vessels; and, secondly, we learn that the spleen is actually distended by the fluid portion of the contents of the stomach.

During the distension of the spleen, when the pylorus was not tied, the rhubarb appeared more strongly in the blood of the splenic than in that of other veins. If coloured solids without fluids were introduced into the stomach, the cells of the spleen were not distended, nor did this organ or its veins give more signs of the colouring matter than others.

Unfortunately, the size of the spleen is considerable, in those warm-blooded animals which never drink; as well as in bisulcous animals, whose spleen adheres to the paunch, receiving the crude food only, but never the drink, which is prevented from entering it by the well-known mechanism of a semicanal running from the œsophagus to the omasum.

From later experiments, published in 1811, the writer completely changed his opinion. It seems that traces of rhubarb were discoverable in the bile as well as in the spleen: and that it tinged

[m] *Phil. Trans.* 1808.

the urine if the spleen had been removed before the experiment: so that the burner of John Hunter's manuscripts abandoned what he had before advanced as a discovery, and regarded the spleen rather as a secreting organ, and its large and numerous lymphatic vessels, running to the thoracic duct, as supplying the place of an excretory canal.

CHAP. VII.

THE FUNCTION OF THE OMENTUM.

"The omentum gastro-colicum or magnum[a] (to distinguish it from the parvum or hepato-gastricum[b]) is a peculiar process of peritonæum, arising immediately from the external coat of the stomach.

"Although there are innumerable continuations of the peritonæum in the abdomen[c], and every abdominal viscus is so covered by it that on opening the abdomen nothing is found destitute of that membrane, nevertheless, it is afforded in different ways, which may be reduced to classes.

"Over some the peritonæum is merely extended as a smooth membrane, or it affords to them only a partial covering, as is the case with respect to the kidneys, rectum, urinary bladder, and, in some measure, with respect to the pancreas and gall-bladder.

"To some which project into the cavity of the abdomen, although adhering to its parietes, it affords a covering for the greater part of their surface; *v. c.* to the liver, spleen, stomach, uterus, and the testes of the very young fœtus.

"The intestinal tube, with the exception of the rectum, projects so much into the cavity of the abdomen, that it is, as it were, suspended in loose processes of the peritonæum, called mesentery and mesocolon: the broad ligaments of the uterus are similar to these.

"The longest and most remarkable process of peritonæum is the *omentum*—a large, empty, delicate sac, hanging from the

[a] "Eustachius, tab. ix.

Haller, *Icones anat.* fasc. i. tab. iv. K. M., and the Appendix Colica, which he himself investigated at Göttingen in 1740. ib. R.

Rob. Steph. Henry, *Descript. omenti c. icone nova.* Hafn. 1748. 4to."

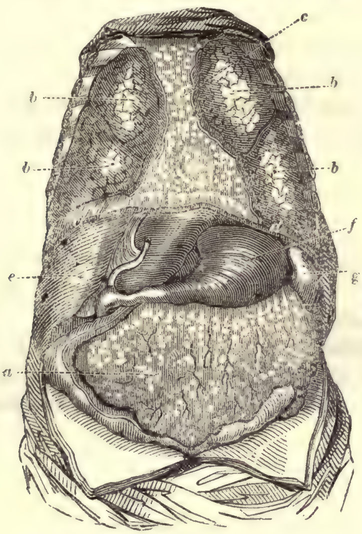
[b] "Eustachius, tab. x. fig. 1. G. H.

Haller, l. c. Q."

[c] "C. J. M. Langenbeck, *Commentarius de structura peritonæi,* &c. Gött. 1817. 4to. with copper-plates."

large curvature of the stomach, extending over the greater part of the small intestines, applying itself closely to their convolutions, and, in some measure, insinuating itself into their interstices.

" Besides the blood-vessels seen upon the omentum, it is marked by fatty striæ or bands, which are every where reticulated (whence the German name (Netzhaut) of this membrane), and in corpulent persons increase occasionally to a large and even dangerous size; and, by their means, the whole omentum is lubricated with a halitus, which one might almost call adipose.



a, omentum.
b, lungs.
c, mediastinum.
d, diaphragm.
e, liver.
f, stomach.
g, spleen.

" On the latter circumstance depends the use commonly ascribed to the omentum, — of lubricating the intestines and assisting their continual movements: this also appears the use of those analogous small bursæ which are found[d] in such numbers about the rectum[e] and colon.[f]

" The omentum also prevents the adhesion of the intestines to the peritonæum, and the consequent impediment to the functions of the primæ viæ.

[d] " I have lately seen similar appendices on the peritonæal covering of an uterus unimpregnated, but which had formerly been pregnant."

[e] " Walter, tab. ii. *m. m. m.*"

[f] " Bidloo, *Anatomia hum. corporis*, tab. xxxix. fig. 6. C.C.C. D.D.D."

"There is another two-fold office attributed with great probability to the omentum [g], *viz.* that of facilitating the dilation of the viscera to which it is contiguous, and of acting as a diverticulum to their blood during their state of vacuity.

"If we reflect on the singular structure of the omentum parvum or hepato-gastricum especially, we may be inclined to believe that there is another, and perhaps, principal office attached to it, unknown at present, and discoverable by comparative anatomy."

[g] "v. Chaussier, *Mémoires de l'Acad. de Dijon*. 1784. Semestr. iii. p. 95."

CHAP. VIII.

THE FUNCTION OF THE INTESTINES.

"The intestinal tube, over which the omentum is extended, and which receives the chyme to elaborate it further and separate the chyle from the fæces, is divided into two principal portions—the small and large intestines, of whose functions we shall speak separately.

"The small[a] intestines are again divided into three: the duodenum, jejunum, and ileum.

"The first is named from its usual length.

"The second from generally appearing collapsed and empty.

"The third from its convolutions: it is the longest of the three, fuller, and, as it were, inflated, and sometimes resembling the large intestines by the appearance of bullæ.

"The coats of the small intestines correspond with those of the stomach.

"The *external* is derived from the mesentery.

"The *muscular* consists of two orders of fibres: the one longitudinal, interrupted, external, and found especially about the part opposite the mesentery; the other, annular and falciform, possessing the power of narrowing the canal, while the former shortens it. Upon both depends the very great and permanent irritability of the intestines, formerly mentioned.

"The *nervous* coat is condensed cellular membrane, easily reduced by handling, or more particularly by inflation, into a spumous tela[b]; in it the intestinal blood-vessels, which arise from the mesenteric[c], are distributed in a beautifully arborescent

[a] "Chr. Bernh. Albinus, *Specimen anat. exhibens novam tenuium hominis intestinor. descriptionem.* LB. 1724. 8vo."

[b] "B. S. Albinus, *Annotat. Academ.* L. ii. tab. iv. fig. 1, 2."

"Eustachius, tab. xxvii. fig. 2. 4."

form[d]; the intestines, no less than the stomach, are indebted to it for their tenacity and strength.

"The interior, lined by its delicate epithelium, and deserving the name of *villous* in the small intestines more than in any other part of the canal, forms, in conjunction with the inner surface of the former coat, here and there, undulated ridges and rugous plicæ, which, in dried and inflated intestines, resemble the blade of a scythe, and are termed the valvulæ conniventes or Kerkringhianæ.[e]

"The *villi*, which are innumerable[f] upon the inner surface of the intestines, and whose beautiful and minute vascular structure was first carefully investigated, though described with exaggeration, by Lieberkühn[g], may be, perhaps, compared, while destitute of chyle, to little loose pendulous bags, internally soft and spungy; but, when distended with chyle, they have the appearance of a morel.

"The base of these villi is surrounded by innumerable *glandular follicles*, adhering chiefly to the nervous coat, and opening into the intestinal canal by a very small orifice, through which they discharge the mucus that lines the whole track of the intestines.

"These are distinguished into three orders. The Brunnerian, largest, solitary, found in most abundance in that part of the duodenum which is contiguous to the pylorus.[h] The Peyerian, smaller, aggregated, found chiefly at the termination of the small intestines,—about the valve of the colon.[i] Lastly, the Lieber-

[d] "B. S. Albinus, *Dissert. de arteriis et venis intestin. hominis,* with coloured plates. LB. 1736. 4to.

Also his *Annotat. Acad.* L. iii. tab. i. ii."

[e] "Kerkring, *Spicilegium anatomicum,* tab. xiv. fig. 1, 2."

[f] "He estimated their number, in the small intestines of an adult, to be about 500,000."

[g] "*De fabrica et actione villorum intestinor. tenuium hominis.* LB. 1745. 4to.

J. Bleuland, *Descriptio vasculorum in intestinorum tenuium tunicis.* Ultraj. 1797. 4to.

R. A. Hedwig, *Disquisitio ampullarum* Lieburkühnii. Lips. 1797. 4to.

C. A. Rudolphi, *Anatomisch-physiologische Abhandlungen.* Berlin. 1802. 8vo. p. 39."

[h] "J. Conr. a Brunn, *Glandulæ duodeni s. pancreas secundarium.* Francof. 1715. 4to. fig. 1."

[i] "J. Conr. Peyer, *De Glandulis intestinorum.* Scafhus. 1677. 8vo. especially fig. 3."

kühnian, the smallest, said to be distributed in the proportion of about eight to each villus.[k] The two former orders are so inconstant, that I am inclined to consider the view given of them in the plates alluded to, as morbid[l]; for I have more than once been unable to discover the slightest trace of fungous papillæ with a single pore, in the small intestines of healthy adults; while, on the contrary, in *aphthous* subjects, I have found nearly the whole intestinal tube beset with them in infinite numbers, both solitary and aggregated.[m]

" As the gastric juice is poured into the stomach, so an *enteric* or *intestinal fluid* is poured into the small intestines, demonstrated, among other ways, by the common experiment, first, we believe, instituted by Pechlin[n]," of including a portion of intestine between two ligatures, so that the fluid secreted into it may be collected. " An accurate investigation of it is a physiological desideratum. We can say nothing respecting its quantity, but Haller's estimate — eight pounds in the twenty-four hours — is certainly excessive.

" The intestines agree with the stomach in this particular, that they have a similar, and, indeed, a more unquestionable, or, at least, a more lively, *peristaltic action*[o], which occurs principally when the chymous pulp enters them. This it agitates by an undulatory constriction of different parts of the canal, and propels from the duodenum towards the large intestines. Although the existence of an antiperistaltic motion, causing a retrograde course to their contents, cannot be disproved, it is in health much weaker, and less common and important, than the former.

" By these moving powers, and by these solvents which are afforded by means of secretion, the chyme undergoes remarkable changes."[p]

[k] " Lieberkühn, l. c. p. 17. tab. iii."

[l] " The eminent Rudolphi thinks differently, l. c. p. 212."

[m] " These intestinal *aphthæ* exactly resemble those tubercles which Sheldon, in a work which we shall presently quote, exhibits (Tab. 1.) as small ampullæ full of chyle."

[n] " *De purgantium medicamentor. facultat.* p. 509. — tab. iv."

[o] " Benj. Schwartz, *De vomitu et motu intestinorum.* LB. 1745. 4to.
J. Foelix, *De motu peristaltico intestinorum.* Trevir. 1750. 4to."

[p] " Consult the excellent observations and experiments of A. E. Ferd. Emmert, *Archiv für die Physiologie*, t. viii. p. 145."

Albumen and albuminous substances, which are the source of the chyle and so abundant in the duodenum and jejunum, gradually disappear, so that a great part of the chyle is generally formed and absorbed before the digested mass reaches the ileum.[q] The contents become of a brownish yellow colour, and of a disgusting odour.

"After becoming more and more inspissated in their long course through the ileum, they have to overcome the valve of the colon and pass into the large intestines. To facilitate this, the extremity of the ileum is lubricated very abundantly by mucus.

"The *valve of the colon*[r], or, as it may deservedly be termed after its discoverer, the valve of Fallopius[s], is a short process or continuation of the portion of the ileum that penetrates into and is surrounded by the cavity of the large intestine. Its external lips, while a neighbouring fold of the large intestine at the same time projects considerably, are composed[t], not like other similar folds, merely of the interior and nervous coats, but

[q] Dr. Prout, Thomson's *Annals of Philosophy*. 1819.

[r] "Haller, *De valvula coli*. Gotting. 1742. 4to., reprinted in his *Oper. minor.* t. i. p. 580. sq.

T. Mich. Röderer, *De valvula coli*. Argent. 1768. 4to."

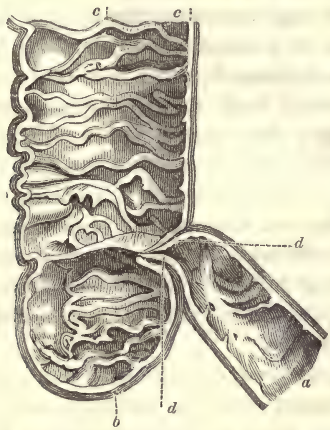
[s] "The various opinions respecting the discoverer of this remarkable valve are well known. Haller's *Elementa*, t. vii. P. I. p. 142., may be consulted on this point.

In the mean time I am certain that, long before the period at which its discovery is in general dated, it was accurately known to that immortal anatomist Gabr. Fallopius. In the library of our university there is a manuscript of Fallopius, containing, among other things, his *anatomy of the monkey*, in which is an account of the structure and use of the valve of the colon, delivered in a public demonstration at Padua, Feb. 2. 1553, in the following words: '*The use of the cæcum in the monkey is to prevent the regurgitation of the food during progression on all fours. This is proved by the circumstance of water or air, thrown into the rectum, reaching the cæcum, but not passing beyond the large intestines. But, if impelled from above, it passes into them. The reason is this, — at the insertion of the ileum are two folds, which are compressed by inflation and repletion, as occurs in the heart, and prevent retrogression; wherefore, in man, clysters cannot pass and be rejected through the mouth, unless in a weak and diseased state of the intestines.*'"

[t] "A view of a recent and entire valve is exhibited by B. S. Albinus in his *Annotat. Acad.* L. iii. tab. v. fig. 1.

And overcharged by inflation and drying, in Santorini's Posthumous Tables, xiv. fig. 1, 2."

of fibres from the muscular coat also. Hence it performs the double office of preventing the passage of too great a quantity of fæces into the large intestines, and regurgitation into the small."



a, ileum.
b, cæcum.
c, colon.
d, valve.

It probably always prevents regurgitation even of air, while entire: and the contents of the ileum are so often seen fæcal in dissection, that stercoraceous vomiting is no argument that the valve occasionally allows retrogression of the intestinal contents.[u]

" The large intestines, divided like the small into three parts, commence by the *cæcum* (which has a *vermiform process* whose use in man is unknown [x]), and afford a very ample receptacle, in which the fæces may be collected and retained, till an opportunity for discharging them arrives.

" They exceed the small intestines in thickness and strength, as well as in capacity. The muscular coat has this peculiarity— that its longitudinal fibres, excepting at the extremity of the rectum, are collected into three bands, called ligaments of the colon [y]; and the intestines themselves are divided into a kind of bulbous segments. The inner coat is not so beautifully flocculent as that of the small intestines, but more similar to that of the stomach.

[u] *New Views of the Process of Defecation, &c.* By James O'Beirne, M.D. Dublin, 1833, p. 16. sq.

[x] " Lieberkühn, *De valvula coli et usu processus vermicularis.* LB. 1739. 4to. Joach. Vosse, *De intestino cæco ejusque appendice vermiformi.* Gotting. 1749. 4to."

[y] " Eustachius, tab. x. fig. 2. 4, 5."

"Their peristaltic motion is much fainter than that of the small intestines. On the other hand, they experience to a greater degree the pressure of the abdominal parietes, to which the whole length of the *colon* is contiguous."

On arriving in the large intestines, the mass of contents undergoes fresh changes, at present unexplained, and is converted into true excrement or fæces.[z] Here it is that a peculiar *succus entericus* must be poured forth, for the secretion into the small is probably nothing more than mucus and a simple watery fluid. Tiedemann and Gmelin support, in some measure, the old idea of the cæcum being a subsidiary stomach, from its contents being acid although acidity had disappeared higher up in the canal, and more acid as the aliment is less digestible; and from albumen often reappearing suddenly in this part of the canal. Dr. Prout found the fluids of the large intestines coagulate lymph even as low as the rectum.

The excrementitious mass, consisting of the indigestible part of the food, the resinous colouring and fatty matters of the bile, with intestinal mucus, loses its fluids gradually as it descends, and in the lower part of the intestines becomes particularly dry.[a]

The fæces appear to accumulate in the sigmoid flexure of the colon, the lower and greater part of which, when empty, falls into the pelvis, hanging doubled over. As the fæces accumulate, this turns upon the rectum, until at length, like the stomach, its greater arch is placed forwards and upwards, and its contents are brought somewhat perpendicular to the upper end of the rectum. When the accumulation amounts to a certain degree, that intestine and the abdominal muscles and diaphragm are excited to simultaneous action, the whole contents pass down into and force open the rectum, which, in its turn, is presently excited in the same way, and the same powers[b] "overcome the resistance of the os coccygis and of both sphincters, the inner of which is a remarkable bundle of circular fibres, the outer, a truly cutaneous muscle. After the excretion, the effort of the abdomen having ceased, the levator ani chiefly retracts the intestine, which is again closed by its sphincter."[c]

[z] See Abernethy, *Surgical Observations*, Part II. p. 34.

[a] The excrements of brutes have been analysed, but not to an extent capable of affording general views.

[b] Dr. O'Beirne, l. c.

[c] "All these parts may be seen as they exist in each sex, in Santorini's Posth. Tables, xvi. and xvii."

It is generally believed that the fæces collect in the rectum, till their quantity

"The discharge is facilitated by the absence of transverse rugæ, and especially by the great quantity of mucus at the extremity of the bowels."

The alimentary canal always contains gaseous substances, which, being chiefly disengaged from its contents, must vary at different parts of the canal. These serve the important purpose of gently causing the canal to open progressively for the advance of soft or solid contents.

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stimulates it to discharge them. Dr. O'Beirne, in his very original work, argues successfully against this, 1st, from the inconvenience to the bladder and the constant irritation of the sphincter ani, were accumulation to occur there, so that the rectum is ill circumstanced for accumulation, whereas the cæcum and colon really appear constructed for receptacles. 2d, The sigmoid flexure is a great depôt for fæcal matter, and therefore a free passage at all times into the rectum is unlikely. 3d, Great force is usually required to force injections up the rectum, as if it were naturally contracted and close. 4th, The finger or an instrument introduced into the rectum is rarely soiled by fæces. 5th, Adhesions within the rectum have often been found, but seldom or never in the other intestines, and they must require an empty condition of the cavity for the necessary contact of the sides. 6th, After division or destruction of the lower sphincter of the anus, the fæces are generally retained as usual. 7th, He has examined the rectum with a long tube in many healthy persons several times a day, and never found fæces in it. Besides the muscular fibres possessed by the rectum in common with the colon, it has strong fleshy fibres, circular and longitudinal, and it alone receives nerves of sense and motion from the spinal marrow.

Dr. O'Beirne considers, also, that an accumulation naturally occurs in the cæcum as well as in the colon, from the great acuteness of the angle at which the ileum enters the cæcum; the greater capacity of the cæcum than of either the ileum or colon; the course of the colon against gravity; the necessity of the cæcum being filled before it can be excited to or supported in an expulsive effort; and the distention of the colon all the way from the cæcum to the sigmoid flexure by gas, which prevents the ascent of the fæces from the cæcum till it escapes from the lower bowel. He conceives that the whole contents are transferred at once: and as, at the time of defecation, there is usually one mass in the sigmoid flexure and one in the cæcum, that the amount of the two is the evacuation; and as two distinct acts of expulsion are always required before the bowels in health are sufficiently freed, that the capacity of the rectum may be received as the measure of that of the cæcum. When he has had every reason to believe that no fæces were in the sigmoid flexure, from a hollow bougie passed into it remaining unsoiled, flatus escaped; and, on passing the instrument again in five minutes, its upper extremity has been coated with fæces, and a solid evacuation soon occurred.

I think that the sympathy between the stomach and the large intestines, when these are charged, deserves notice. When the intestinal contents have accumulated, the repletion of the stomach by even a moderate meal excites the lower portion of the canal to discharge its contents, so that a meal at such a time causes a desire for relief, and the more as the meal is greater.

The gas of the stomach contains, besides azote and carbonic acid gas, oxygen, and very little hydrogen; while that of the small intestines contains, besides the two former gases, no oxygen, and abundance of hydrogen: that of the large intestines has less hydrogen and carbonic acid, and likewise no oxygen. Little or no gas is found in the stomach during chymification.

The following are the results of MM. Magendie's and Chevreuil's analysis of the gases of the alimentary canal:

In the stomach of a man just executed,—

Oxygen - - -	11·00
Carbonic acid - - -	14·00
Pure hydrogen - -	3·55
Azote - - -	71·45
	100·00

In the small intestines of a subject, four-and-twenty years of age, who had eaten, two hours before execution, bread and Gruyère cheese, and drunk eau rougie,—

Oxygen - - -	0·00
Carbonic acid - -	24·39
Pure hydrogen - -	55·53
Azote - - -	20·08
	100.00

——— twenty-three years of age, who had eaten the same food, and was executed with the former,—

Oxygen - - -	0·00
Carbonic acid - -	40·00
Pure hydrogen - -	51·15
Azote - - -	8·85
	100·00

——— twenty-eight years of age, who, four hours before execution, had eaten beef, bread, lentils, and drunk red wine,—

Oxygen - - -	0·00
Carbonic acid - - -	25·00
Pure hydrogen - -	8·40
Azote - - -	66·60
	100·00

In the large intestines of these three criminals, were found,—

Oxygen - - -	0·00
Carbonic acid - -	43·50
Carburetted hydrogen and some traces of sulphuretted hydrogen	5·47
Azote - - -	51·03
	100·00

Oxygen - - -	0·00
Carbonic acid - -	70·00
Hydrogen and pure carburetted hydrogen - -	11·06
Azote - - -	18·04
	100·00

The gas of the cæcum and rectum of the third was examined separately.

Cæcum,—

Oxygen - - -	0·00
Carbonic acid - -	12·50
Pure hydrogen - -	7·50
Carburetted hydrogen -	12·50
Azote - - -	67·50
	100·00

Rectum,—

Oxygen - - -	0·00
Carbonic acid - -	42·86
Carburetted hydrogen -	11·18
Azote - - -	45·96
	100·00

Some traces of sulphuretted hydrogen appeared upon the mercury before the last analysis was commenced.

Berzelius finds human excrement to consist of

Water - - -	73·3
Remains of vegetable and animal matter - - -	7·0
Bile - - -	0·9
Albumen - - -	0·9

Peculiar extractive matter -	2·7
Matter composed of altered bile, resin, animal matter, &c. -	14·0
Salts - - -	1·2
	100·0 [d]

Besides the gases disengaged from the contents of the canal, at least the stomach contains a portion of air that has been swallowed with the food, and many persons can easily *swallow air by itself.* Air is perhaps generated occasionally in the womb, and is undoubtedly generated by serous membranes. Emphysema has occurred without any wound of the lungs. I believe, with John Hunter [e], that the alimentary canal also often secretes gaseous fluids. For mental emotion will suddenly cause extreme discharges of air from the stomach, and the intestines to swell with wind. Want of food fills the stomach with wind. In many diseases the same will occur, although no fermentation or unusual change is discernible in the contents of the canal.

Air in the serous membranes, or in the cellular, even when introduced, is known to be absorbed. [f]

Every one knows that the intestines are usually relieved once in twenty-four hours, but that some little variety occurs in this respect. In cases of extreme abstinence, they of course discharge their contents very rarely, as I mentioned formerly. Heberden, however, mentions a person who naturally had a motion once a month only, and another who had twelve motions every day during thirty years, and then seven every day for seven years, and rather grew fat than otherwise. [g] Habit has the greatest influence upon defecation.

Pouteau's young lady, mentioned at page 55., had no stool, he says, for upwards of eight years, although during the last year she ate abundantly of fruit, and drank coffee, milk, and tea, and broth with yolks of eggs: but she had copious greasy sweats.

[d] *Traité de Chimie*, tom. vii. Traduit par M. Esslinger.

[e] *Observations on certain Parts of the Animal Economy.*

[f] See Dr. Baillie in *Transact. of Society for Improvement of Med. and Surg. Knowledge*, vol. i.

[g] *Commentarii*, p. 14.

CHAP. IX.

THE FUNCTION OF THE ABSORBENT VESSELS.[a]

"THE course of the chyle[b] from the intestines to the blood is through a part of the absorbent system."

"This is divided into four parts — *lacteal* and *lymphatic vessels, conglobate glands*," (or *ganglia*, as they are now often termed,) "and the *thoracic duct*. Each of these will be now considered.

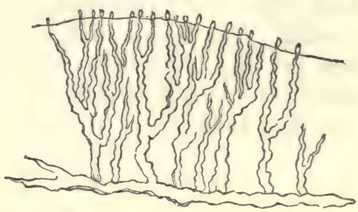
"The *lacteals* originate among the villi of the internal coat of the intestines;" but most writers have been unable to detect their origin. Lieberkühn and Cruikshank, however, appear to have been successful. The former says, that each villus is a lacteal with valves, swelling into a bulb or ampulla at its termination, on the summit of which is an orifice. The latter opened a woman who had died suddenly of convulsions after taking a hearty supper in perfect health. "Many of the villi," he says, "were so full of chyle that I saw nothing of the ramifications of the arteries and veins; the whole appeared as one white vesicle, without any red lines, pores, or orifices whatever. Others of the villi contained chyle, but in a small proportion; and the ramifications of the veins were numerous, and prevailed by their redness over the whiteness of the villi. In some hundred villi I saw the trunk of a lacteal forming a beginning by radiated branches. The orifices of these radii were very distinct on the surface of the villus, as well as the radii themselves seen through the external surface, passing into the trunk of the lacteal: they were full of a white fluid. There was but one of these trunks on each villus. The orifices in the villi of the jejunum, as Dr. Hunter himself said, (when I asked him, as he viewed them in the microscope, how many he

[a] "A very copious list of writers upon the absorbents will be found in Sömmerring's work, *De morbis vasorum absorbentium corporis humani.* Francof. 1795. 8vo."

[b] "Ant. Müller, *Experimenta circa chylum.* Heidelb. 1819. 8vo."

thought there might be,) were about fifteen or twenty in each villus; and in some, I saw them still more numerous." [c]

M. Cruveilhier opened a man who had died with scrofulous disease of the mesenteric ganglia and coats of the lacteals and intestines, the latter being ulcerated. The lacteals were distended with both a cheeselike substance and another like cream. This circumstance displayed them fully. From the floating margin of the valvulæ conniventes, innumerable lacteals ran straight and parallel to each other; their numbers were such, that the cellular membrane between the layers of the mucous membrane almost seemed to consist of them. They, few or more, united, and terminated, sometimes at nearly right angles, in long vessels, which ran pretty much in the direction of the valvulæ conniventes at their fixed margin, and each of these passed a considerable way under the peritoneal coat without connection, not forming a network, as is usually represented.



M. Cruveilhier states, that some papillæ of the intestines have black summits, and in these he could never detect a lacteal: that others have yellow summits, and in the centre of such he has found a lacteal, thread-like, conical, or bulbous, according to its degree of distention. The papillæ, each with its lacteal, project and float about in water like the fibres of roots. He has never detected the orifices.[d]

" The trunks just mentioned run some inches along the surface of the intestines, under the external coat, sometimes meandering in an angular course, before they reach the mesentery."

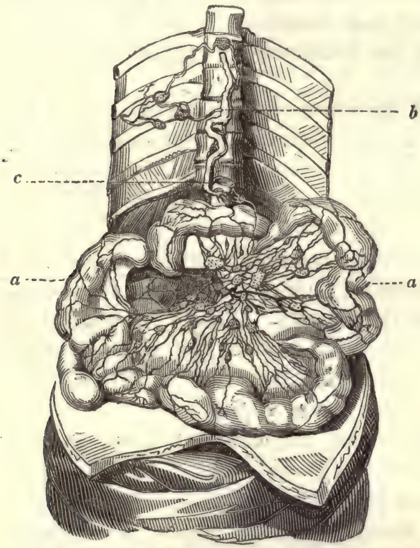
The lacteals are abundantly supplied with valves.

" In their course through the mesentery they run into the mesenteric *glands*," (or *ganglia*,) " of which there are two series.

[c] *Anatomy of the Absorbing Vessels*, p. 59.

[d] *Anatomie Pathologique du Corps Humain.* Deuxième livraison, p. 1. sqq. Paris, 1830.

The one nearer the intestines, dispersed, small, and resembling beans in shape; the other, nearer the receptaculum chyli, large and aggregated."



a, Small intestine, so pushed aside as to display the lacteal vessels running from them to their glands or ganglia in the mesentery.
b, The thoracic duct, ascending in front of the spine.
c, The aorta cut short.

If a gland is well injected, the numerous ramifications of the absorbents prevent cells from appearing, and it seems only a closely compacted collection of lacteals; but, if injected less minutely, cells are very evident, and distinct from the convolutions and ramifications of vessels.[e] "If an absorbent gland of a horse is filled with quicksilver and dried, and then carefully slit open, the cells will be seen of a large size, and bristles may with ease be passed through the openings by which they communicate." It is imagined that the vasa inferentia (or vessels running into a gland) pour their contents into these cells, and that the efferentia (or the vessels running from a gland) afterwards absorb it from them. The inferentia are fewer, in general, than the efferentia of the same gland.

"It has been enquired whether lacteals exist also in the large intestines, and their existence has been advocated, from the effects of particular injections, nutrient, inebriating, &c., and also from the circumstance that the fæces, if retained for any length

[e] Wilson, *Lectures on the Blood, &c.* p. 203. Mr. Abernethy described them in the whale, as well as in the horse. *Phil. Trans.* 1796.

of time, become hard and dry. Although these arguments do not demonstrate the absorption of genuine chyle below the valve of Fallopius, nevertheless it is rendered probable by the visible existence of an abundance of lymphatics in the large intestines [f], having the same structure and function with the lacteals; for these absorb lymph from the intestines [g] during the absence of chyle.

" But the very different structure of the internal coat of the large intestines from that of the villous coat of the small, strongly argues that they are not naturally intended to absorb chyle."

Some contend that the lacteals take up nothing but chyle.

Dr. Magendie [h] asserts that neither he nor Hallé has ever seen the chyle in these vessels tinged by coloured ingesta, and that neither he nor the veterinary surgeon Flandrin ever found any thing but chyle enter the lacteals. Lister's experiment [i] of making puppies swallow indigo, and finding the contents of the lacteals blue, has succeeded with Musgrave, Haller, Blumenbach [k], John Hunter, Fordyce [l], and numerous others; and J. Hunter, in the presence of several persons, poured milk into the intestines of a dog, and they all observed it quickly to fill the lacteals. Among other insignificant objections, Dr. Magendie urges that J. Hunter should have first noticed whether the vessels contained chyle, whereas it is expressly mentioned that, before the milk was poured into the intestine, the lacteals were seen distended by a nearly colourless and pellucid fluid.[m]

Tiedemann and Gmelin, however, have made an abundance of these experiments with the same result as Magendie, though in some few instances the substance introduced into the canal was discovered in the chyle. Fiscinus and Seilar [n] say exactly the same as Tiedemann and Gmelin. They occasionally could detect metallic salts, and even turmeric and madder, in the chyle. Franchini [o] says, that, when the contents of the lacteals look blue,

[f] " Mascagni, tab. xvi."

[g] " See Nuck, *De inventis novis ep. Anatomica*, p. 146. sq."

[h] *Précis Elémentaire*, &c. t. ii. p. 178. sq.

[i] *Phil. Trans.* No. 143. compared with No. 275.

[k] *Instit. Physiol.* § 422.

[l] *On the Digestion of the Food*, p. 122.

[m] *Medical Commentaries*.

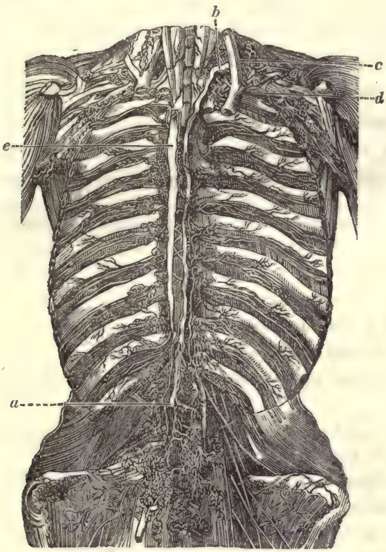
[n] Dresden. Republished in the *Journ. Complémentaire du Dictionnaire des Sc. Med.*

[o] Bologna. 1823.

they prove limpid on being let out; and that when red substances have been swallowed, and they look red, this arises from the abstinence, which always causes the fluid of both lacteals and lymphatics to become red.

"The ultimate trunks of the lacteals, arising, like the lymphatics, from the combination of a great number of small twigs [p], unite into the *receptaculum* or *cisterna chyli*, — the appellation by which the lower and larger part of the *thoracic* or PECQUETIAN *duct* is distinguished.

"This duct is [q] a membranous canal," consisting of an external fibrous, and a smooth inner serous coat, "slender, strong, more or less tortuous, subject to great varieties in its course and division [r], and possessing here and there valves. At about the lowest cervical vertebra, after passing the subclavian vein, it turns back again [s], and is inserted into this, being furnished with a peculiar valve at the point of insertion.



a, receptaculum chyli.
b, upper end of the thoracic duct, which bends behind
c, the internal jugular vein, and terminates in
d, the angle of the jugular and subclavian veins.
e, vena azygos.

[p] "Sheldon, l. c. tab. v."

[q] "See Haller, *Observationes de ductu thoracico in theatro Gottingensi factæ.* Gotting. 1741. 4to.

B. S. Albinus, *Tabula vasis chyliferi.* LB. 1757. large folio.

Mascagni, tab. xix."

[r] "See *v. c.* J. C. Bohl, *Viæ lacteæ. c. h. historia naturalis.* Regiom. 1741. 4to. Sömmerring, *Commentat. Soc. Scient. Gottingens.* t. xiii. p. 111."

[s] "*v.* Haller, *Opera Minora*, vol. i. tab. xii."

"The motion of the chyle throughout its course is to be ascribed to the contractility of its containing vessels, to their valves, and to the vis-a-tergo."

The force of their contraction is shown by the rupture of the thoracic duct from over-distention when a ligature is passed around it.[t] Tiedemann and Gmelin saw the thoracic duct contract from exposure to air.

"The use of the valve placed at the opening of the thoracic duct is probably not so much to prevent the influx of blood, as to modify the entrance of the chyle into the vein, — to cause it to enter by drops.

"By this contrivance, fresh chyle is prevented from having access to the blood so rapidly as to stimulate the cavities of the heart too violently and be imperfectly and difficultly assimilated.

"These *lymphatics*[u], which constitute the third part of the absorbent system, and resemble the lacteals in their structure and function, are much more, and perhaps, indeed, universally, diffused.[x] They arise principally from the cellular membrane, which we may call the grand bond of connection between the sanguiferous and absorbing system; but in great numbers likewise from the external common integuments[y], from the fauces, œsophagus," and all mucous membranes, "the pleura, peritonæum," and all serous membranes, from all excretory ducts, from arteries[z], and

[t] Sir Astley Cooper, *Med. Records and Researches.* A ligature of the thoracic duct does not necessarily deprive the body of nourishment, because there are sometimes two ducts, and sometimes one or more small trunks which unite with it or have a different termination in the venous system.

Dr. Magendie observed in the dog, that the contents of the thoracic duct flow but slowly; though more quickly during compression of the abdominal viscera. On wounding it after a meal, he obtained half an ounce in five minutes, and they flowed for some time.

[u] "Consult, among others already and hereafter quoted, J. F. Meckel, *De vasis lymphaticis glandulisque conglobatis.* Berol. 1757. 4to.

And Al. Monro, filius, *De venis lymphaticis valvulosis.* Ib. same year. 8vo."

[x] Dr. W. Hunter, *Medical Commentaries*, P. i. p. 5. sq.

[y] "J. Elliotson has adduced new arguments showing that cutaneous absorption has been doubted of late without good reason, in his notes to the English translation of these *Institutions*, p. 129. 3d edit. 1820."

[z] Lymphatics may be injected from arteries. Lippi says that he finds many arise from arteries; and they probably originate from them as they do from every other part of the body. But to imagine they arise from arteries only is incorrect; and to imagine their sole function to be absorption from arteries, absurd. Dr. Magendie, however, attempts to revive the old opinion of lymphatics arising from arteries only and being destined to convey lymph from them.

from the substance of the "thoracic and abdominal viscera," in short, from every part, at least, where there is moisture.[a]

"Their origin is similar to that of the lacteals in the intestines, so that the radicle of each lymphatic absorbs the fluid from the surrounding spot, as from its territory, and propels it onwards.

"The lymphatics," like the lacteals, "have double valves, set more or less thickly in different parts; they almost all enter conglobate glands," perfectly similar to the mesenteric, diffused throughout the body, and aggregated in some situations, as in the groins and axillæ: "those lymphatics which are contiguous to each other anastomose here and there, and those found on the surface of certain viscera, as the lungs, liver, &c., form a most beautiful network." In the extremities, they run in two sets, — one deep-seated and accompanying the arteries, the other superficial and accompanying the subcutaneous veins.

"Besides other aids to their functions, evident from what has already been said, no inconsiderable assistance is derived from the combination of great strength with thinness of their coats by which they are enabled to support a heavy column of quicksilver. In the limbs, especially, the motion of the muscles, pressing them on every side, is highly useful in increasing their power."

Dr. Carson argued that the thoracic vacuum, which is explained in the chapter on respiration, would not only draw the blood along the veins, but draw it into their open mouths, thus being an agent of absorption. He concluded that the blood of the corpora cavernosa penis enters the veins in this way, but, as the lymphatics only were believed the organs of absorption, properly so called, when he first wrote, he had not a more extended idea of the co-operation of the vacuum in producing venous absorption. It must, however, evidently extend to every absorbing vein, and if the veins absorb generally, as some now believe, it must be general. As the great trunk of the absorbents terminates in a vein, they must be circumstanced in this respect exactly like veins, and equally subject to the influence of the thoracic vacuum. Indeed, Dr. Barry, in a work quoted in the chapter on respiration, found that while a cupping-glass was applied over a wound to which poison was applied, no ab-

[a] "Mascagni, tab. i. ii. iii.

T. Gottl. Haase, *De vasis cutis et intestinorum absorbentibus*, &c. Lips. 1786. fol. tab. i."

sorption occurred, no poisonous effects ensued; nor did they, even for some time afterwards; and when they became apparent, they instantly subsided on the re-application of the glasses. The pressure of the rim of the glass, he says, was not the cause of the non-appearance of poisoning, because if the deleterious substance was passed under the skin beyond the boundary of the glass, no ill effect occurred as long as the glass remained over the wound: an incision between the site of the poison and the rim destroyed the efficacy of the glass.[b] Yet others have found the same result from the cupping-glass pressed down and not exhausted, and even from the pressure of a solid body.[c]

Dr. Barry's experiments, however, would not prove that atmospheric pressure is the cause of absorption: they would merely show its co-operation, and that the propulsive powers of the absorbents are insufficient when opposed by the removal of it. Pecquet, nearly two centuries ago, considered whether the chyle was absorbed by suction; and concluded against the opinion, by observing, that, if a ligature was placed upon the thoracic duct or the lacteals of the mesentery, and all effect of vacuum thus prevented, the lacteals swelled on the intestinal side; therefore, said he, "non trahitur chylus sugiturve."[d]

The pressure of ordinary respiration and of muscular efforts is also seen to drive the chyle forwards in the lacteals.

"But their principal action, by which they take up fluids more or less rapidly, eagerly absorbing some and absolutely rejecting others[e]," like the lacteals, "depends upon the peculiar modifica-

[b] *Experimental Researches*, p. 102. The application of a vacuum in poisonous wounds has been recommended from the days of Hippocrates to those of Dr. Parry (*Cases of Tetanus and Canine Hydrophobia*), but its effects never shown so beautifully as by Dr. Barry. He recommends that the cupping-glasses should be first applied for an hour; that, the suppression of absorption for some hours being thus ensured, the part should be excised, and then the glasses re-applied to remove any portion of the poison that may remain, for the vacuum was found to extract some of the poison.

[c] See the translation, by Drs. Hodgkin and Fisher, of Dr. Edwards's work, hereafter quoted, p. 401. sq.

[d] *Dissertatio Anatomica de circulatione sanguinis et chyli motu*, p. 76. Paris, 1651.

[e] "On this remarkable difference consult T. Fr. Lucr. Albrecht, *Commentatio* (honoured with the Royal Prize) *in qua proponitur recensus eorum alimentor. et medicaminum, quibus, sive tubo alimentario sint ingesta, sive communibus corporis integumentis applicata, ingressus in systema vasor. sanguifer. aut concessus a natura, aut negatus sit.* Gotting. 1806. 4to."

tion of their vitality, and is acribed by the very acute Brugmans to a certain *vita propria*.[f]

"A great part of these lymphatics terminate in the thoracic duct; not, however, those of the right arm, the right side of the neck, the right lung, and the right portion of the diaphragm and liver, which terminate in the subclavian vein of the same side." Many other connections have been seen between absorbents and veins. Mr. Bracy Clarke discovered communications in the horse between the thoracic duct and lumbar veins[g], and Mr. Abernethy, Steno, Seiler, Mertrud, &c. traced lymphatic vessels to veins; Wepfer traced the absorbents of the broad ligaments into the hypogastric veins; Nuck, those of the arm into the lumbar veins; Lobstein, those of the spleen into the vena portæ; Tiedemann and Gmelin, like many before them, have propelled mercury into the vena portæ by absorbents; Mr. Cruikshanks long ago remarked, that, in animals destroyed by violence, the lymphatics about the spleen and in the cavity of the abdomen, in peritoneal inflammation sometimes the lacteals, and in peripneumony the lymphatics of the lungs, are tinged with blood, though no extravasation has occurred, and therefore he believed that lymphatics arise from the internal surface of arteries and veins[h]; the connection of the lymphatics with the veins, in the four classes of vertebrated animals, has of late years been demonstrated by Lippi, Fohmann, and Louth, and in the Anatomical Museum of Heidelberg are numerous beautiful specimens, showing this fact[i]; Lippi[k] has shown that the absorbents of the abdomen terminate abundantly in the branches of the vena portæ, as well as in the iliac, spermatic, renal, lumbar veins, &c. in the venous trunks, and in the veins issuing from conglobate glands, and become continuous with the capillary veins; indeed, that many terminate in the very pelvis of the

[f] "Conr. Jer. Ontyd (Præsidente Seb. Just. Brugmans), *De causa absorptionis per vasa lymphatica*. Lugd. Bat. 1795. 8vo. p. 45.

v. Al. Van Hees, *De causa functionis absorbentis systematis lymphatici*. ib. 1817. 4to. p. 38."

[g] Rees's *Cyclopædia*: Anatomy, Veterinary.

[h] *On the Absorbents*, p. 50.

[i] Mr. Coulson's edition of Mr. Lawrence's translation of Blumenbach's *Manual of Comparative Anatomy*, p. 172.

[k] *Illustrazioni fisiologiche e pathologiche del sistema linfatico-chilifero mediante la scoperta di un gran numero di communicazioni di esso col venoso*, par Regolo Lippi. Firenze. 1825.

kidney. These terminations explain circumstances which have led many to believe in absorption by veins, and even by veins only, and some to believe in the existence of other canals between parts. Such are the extreme rapidity with which fluids taken into the stomach are discharged by urine: the existence in the urine, but not in the contents of the thoracic duct, of certain articles which have been swallowed, as prussiate of potass: and the existence in the blood, and not in the thoracic duct, of others: and again the detection of others in the urine, and not in the blood, saliva, or nasal mucus.[l] In Tiedemann and Gmelin's experiments, among a variety of substances taken, coloured, odorous, or saline, very few could be detected in the chyle, but many were found in the blood. Raspail says, "The milk of women and other females almost always contains the vegetable juices of their food unchanged, although these are not to be found, I suspect, in the chyle; consequently, I should be inclined to admit that unknown connections exist between the breasts and the mucous surface of the stomach. I should say the same respecting the liver, pancreas, and spleen."[m] Three ounces of diluted alcohol were given by Dr. Magendie to a dog; in a quarter of an hour the blood of the animal had a decided smell of alcohol; the lymph (of the thoracic duct) had none.[n]

Dr. Magendie relates two experiments in which a decoction of nux vomica, introduced into the alimentary canal, produced its usual effects, notwithstanding the thoracic duct was tied and ascertained to be single. In fact, Sir Everard Home, many years ago, found substances to be taken into the circulation and into the urine from the stomach, though the thoracic duct was tied.[o] In a similar experiment, instead of the thoracic duct being tied, Dr. Magendie separated the portion of intestine containing the solution from the body, except in one artery and one vein. In another experiment, not only was every part of a limb separated from the body except the large artery and vein, but even these were cut asunder, quills having been previously introduced into them and fixed to carry on the circulation, and yet some upas plunged into the paw of the animal exerted its peculiar influence, which besides was suspended and permitted at pleasure by compress-

[l] Dr. Wollaston, *Phil. Trans.*, 1811.

[m] l. c. p. 357.

[n] *Précis de Physiol.* t. ii. p. 202. sq.

[o] *Phil. Trans.* 1811.

ing or liberating the vein under the finger and thumb.[p] Dr. Segalas cut a portion of living intestine from the rest of the canal, and passed a ligature around its blood-vessels, leaving the absorbents free, and introduced a solution of nux vomica for an hour without ill effect: he then liberated the vein, and the animal was poisoned in six minutes. Dr. Magendie mentions the following experiments, which, if to be depended upon,

[p] When the poison was placed in a wound, it might contaminate the blood without being taken up by absorbing extremities of vessels; and, if Magendie is right in believing that fluids soak through even *living* solids, we see how very readily it might all reach the blood. It is universally known, that, *after death*, fluids penetrate through the various textures of the body;—the aqueous humour diminishes in the eye, which consequently becomes flat, the intestines near the gall-bladder become yellow, and water poured into the stomach or intestines exudes. (A. Kaau, *Perspiratio dicta Hippocrati*, 563.)—Hence, especially in a hot atmosphere, if the examination of a dead subject is long delayed, parts may become so dyed with imbibed blood, that their redness may be, and often is, mistaken for inflammation. (See an important paper by Dr. John Davy, *Med. Chir. Trans.* vol. x.; also the more recent statements in Dr. Andral's *Précis d'Anat. Pathologie*, t. i. p. 63. sqq.)—Dr. W. Hunter contended that this imbibition occurs also during life, although not in the case of blood-vessels, and others admitted it. (*Med. Commentaries.*)—Dr. Magendie supports the same opinion. After separating a blood-vessel from the surrounding cellular membrane, and laying tincture of nux vomica upon it, the animal was poisoned, and the blood within tasted bitter; ink, placed in the pleura of a young dog, dyed, in less than an hour, the pericardium, heart, and intercostal muscles. Dr. Fodera introduced a solution of prussiate of potass into the pleura, and of sulphate of iron into the abdomen, of a living animal, when the two fluids became blue by union at the diaphragm, in five or six minutes, and instantaneously if a galvanic current was established. (*Journal de Physiologie*, t. iii.)—Still there is not the slightest reason to imagine that the *natural* fluids of parts penetrate their substance during *life* and in a *sound* condition. (See Hewson's arguments against transudation, *Experimental Inquiry*, p. ii.)—Dr. Magendie found absorption (of poisonous matters, for example, applied to surfaces) greatly impeded on rendering the vascular system turgid by injecting water into the veins, and equally accelerated on lessening the repletion by blood-letting. We should expect that the greater the repletion of the sanguineous system, the more difficulty must the contents of the absorbents have to advance, and *v. v.*; and from the wise arrangements observed in every function, we should conceive, that, supposing absorption a vital action, (as I cannot but believe it to be, as soon as a substance has fairly entered the vessel perhaps by mere physical attraction,) the vessels would be less disposed to propel their contents in proportion as repletion exists. How it favours, as Dr. Magendie fancies, the idea of absorption being a mere imbibition through the coats of the absorbents, — a notion unsupported and contradictory to established facts, — I cannot see. (In this I fully agree with Dr. Bostock, *An Elementary System of Physiology*, vol. ii. p. 587. sqq.)

would perhaps show that heterogenous fluids are taken up by absorbents running to veins pretty readily, though rejected by the lacteals which run to the thoracic duct. In the horse, the usual contents of both the large and small intestines are mixed with a large quantity of fluid that gradually decreases towards the rectum, and is therefore absorbed as it passes along the canal. Now, Flandrin, having collected the contents of the lacteals, did not find them smell like this intestinal fluid, whereas the venous blood of the small intestines had a taste distinctly herbaceous; that of the cæcum a sharp taste, and a slightly urinous smell; and that of the colon the same qualities in a more marked degree: the blood of other parts presented nothing analogous. Half a pound of assafœtida dissolved in the same quantity of honey was given to a horse, which was afterwards fed as usual, and killed in sixteen hours. The smell of assafœtida was perceptible in the veins of the stomach, small intestines, and cæcum; but not in the arterial blood, nor in the lymph.[q] But similar experiments, with opposite results, have been made by others. John Hunter, after pouring water coloured by indigo into the peritoneum of an animal, saw the lymphatics filled with a blue fluid. In the hands of MM. Magendie, Flandrin, and Dupuytren, this experiment likewise has failed. Magendie does, however, allow, that, in a woman who died with a collection of pus in the thigh, the surrounding lymphatics were distended with pus to the size of a crow's quill;—a pretty decisive proof that lymphatics absorb, as the lymphatics are not said to have been diseased. The absorbents of fish have no valves except at their termination in the red veins, and may therefore be injected from the principal trunks: the injection passes out of the mouths of the absorbents in numerous streams, and especially on the back, if the skate is employed;—another decisive fact. Peyer, Fallopius, and Kerkring saw bile in lymphatics about the liver. Seiler, Walter, and Lippi, have injected absorbents from various excretory ducts. Mr. Kiernan always readily injects them, and sometimes even the thoracic duct, from the hepatic ducts of the liver. Oudmann and Schreger have more lately made many experiments, and proved absorption by the lymphatics, though they have not proved it does not take place also by veins. Down to Boerhaave and Haller the doctrine that the lymphatics absorb was maintained, and it

[q] *Précis de Physiol.* l. c. t. ii. p. 267.

was first seriously attacked by Dr. William Hunter. Dr. Monro secundus soon afterwards did the same, and commenced a very acrimonious quarrel with Dr. William Hunter for the honour of priority of attack. Dr. Baillie expressly states, that Dr. Hunter had delivered such opinions six years before Dr. Monro professes to have made his discovery, and the world has generally given priority to Dr. Hunter. Dr. Monro had also an equally acrimonious dispute with Mr. Hewson for the honour of the discovery of the lymphatics in fish, but the Royal Society adjudged Hewson the Copley medal in 1769 for the discovery. It is amusing to reflect that the very doctrine, for the honour of having first attacked which so much violence was shown, is now again in high favour with some; and that Dr. Monro would be now lauded had he shown that Dr. Hunter only had attacked it. John Hunter deposited various fluids in the intestines; but, although he found manifest traces of them in the absorbents, he could discover none in the mesenteric veins. In the experiments of Oudmann and Schreger, substances were found in the lymphatics, and not in the veins.

It may be difficult not to suppose that both parties were inaccurate in some of their negative observations.

This appears certain;—1. That the lacteals absorb chyle; and usually, but not invariably, nothing else. 2. That the lymphatics absorb; and, as they terminate so abundantly in veins, and a lymphatic running to a minute vein has just the same right to be called a vein as a lymphatic, we may say that the veins absorb. 3. That lymphatics do not absorb quite indiscriminately; and those which run to veins, perhaps, absorb more indiscriminately than those which continue on as lymphatics and run to absorbent ganglia or glands.

"From the universal existence of the lymphatics, and especially from their great number on the surface capable of absorbing fluids from without, the heterogeneous nature of the lymph must be obvious; and this is further proved by accurately examining it in different parts of a subject; *v. c.* that contained in the hepatic or splenic lymphatics is perfectly different from that in the uterine.

"We will enumerate the principal fluids which are continually absorbed during health, to say nothing of many different kinds of substances taken up during disease. There is, besides the chyle separated from the fæces in the small intestines, the halitus of the

cavities, properly so called, especially that of the fauces and of all the mucous membranes, the more watery part of those secreted fluids which are retained for some time in their ducts, *v. c.* in the breast, the vesiculæ seminales, the gall-bladder, &c. and not a small portion of the stillatitious fluids which are applied to the common integuments. [r]

" The solids, after performing their purpose in the economy, insensibly melt away and are absorbed, as is proved by the absorption of the greater part of the thymus gland during infancy, of the roots of the first teeth, and of the alveoli after the second teeth have fallen out. The constant change of the whole osseous system, arising from the insensible renovation of the bony matter, of which we have treated elsewhere professedly [s], may also be adduced.

" It is therefore evident, since so great a variety of matter is absorbed, and at the same time nothing crude or improper allowed to enter the blood, that there is a necessity for some peculiar medium to previously subact and assimilate the various substances.

" It appears to be the chief office of the *conglobate glands*, which constitute the last part of the absorbent system, to prevent the ill effects upon the heart of the improper admixture of crude fluid [t] with the blood, by assimilating the extremely various fluids more and more to an animal nature, by retarding their motion, and perhaps also by superadding to them some fresh-secreted fluid."

This will appear from the following information given us by chemists: —

The fluid collected from the thoracic duct scarcely differs from milk. It is opaque and white; without smell; sweetish and

[r] " Consult, among others, Valer. Lud. Brera, *Anatripsologia ;* fourth edition. Pavia, 1799. 2 vols. 8vo.

A. J. Chrestien, *De la méthode iatroliptice.* Montpell. 1803. 8vo. In German, Gotting. 1813. 8vo."

[s] " Decade 1. *Collection of the crania of different nations,* p. 27."

[t] " If we consider the winding course which nature has provided for the purpose of changing and assimilating the absorbed fluids before their admixture with the blood, and, on the other hand, the dreadful symptoms, such as palpitation, convulsions, &c., which ensue upon the *artificial infusion* of a minute portion of any mild fluid into the blood, we shall be inclined to believe that those absorptions, which Haller (*De c. h. Funct.* vol. i. p. 281. sq.) endeavours to prove are accomplished by the veins, do really take place by means of the lymphatic system."

alkaline; and separates, like the blood, into a solid and a serous portion: the former is insoluble, and rises to the surface sometimes covered with an oleaginous layer. It contains the same salts as milk, and is affected by re-agents in the same manner.[u] If formed from vegetable food only, it is nearly transparent, may be kept weeks or even months without putrefying, and affords a faintly pink coagulum. If from animal food, it is white and opaque, begins to putrefy in a few days, affords an opaque coagulum which acquires a more marked pink hue by the influence of the atmosphere, and throws upon its surface a white creamy substance. The former gives three times as much carbon as the latter; but the latter, being so much richer gives much more carbonate of ammonia and heavy fixed oil, when subjected to the destructive distillation.[x]

Chyle collected from lacteals is whiter, coagulates less perfectly, or not at all, and does not acquire a red colour by exposure to the air[y], so that sanguification proceeds gradually as the chyle passes towards the left subclavian vein.

Although some albumen is discovered actually in the duodenum, and, as Dr. Prout allows, even in the stomach if animal food has been taken, and some fibrin in the first lacteals, the contents of the absorbents are found to possess more and more of these substances in proportion to their progress towards the left subclavian vein. The chyle contains a certain fatty matter, which is considered as *incipient albumen*, and, in proportion as this decreases, does the quantity of fibrin and albumen increase.

The pink colour, acquired by the coagulum of chyle when exposed to the atmosphere, shows the use of the lungs in sanguification.

White globules exist in the chyle even at a very early period of its formation, and these most probably it is that become co-

[u] Raspail, l. c. p. 356.

[x] Dr. Marcet, *Med. Chir. Trans.* vol. vi. His observations were of course made upon the fluid obtained from brutes. Yet MM. Macaire and Marcet, of Geneva, say that the chyle as well as the blood of herbivorous and carnivorous animals is identical in its ultimate analysis; that whatever food an animal habitually eats, the quantity of nitrogen is essentially the same in both the chyle and blood. There is less nitrogen, they say, in chyle than in blood. *Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève,* t. v. p. 389.

[y] Emmert, *Annales de Chimie,* t. lxxx.

[z] Dr. Prout, in Thomson's *Annals of Philosophy.* 1819. p. 274.

loured when the chyle grows pink by the action of the air. There are also much larger white particles in the chyle, appearing to be formed of the caseous-like and oily principles, and, being insoluble in the serum, naturally assume the globular form.[a]

Dr. Marcet had reason to believe that the appearance of creamy matter floating in the serum of blood occurs most frequently when the food is chiefly animal, and when therefore rich chyle is poured into the blood faster than it can be assimilated. The serum at first appears milky; but it gradually becomes clear, from the creamy matter separating and rising to the surface.

The coagulum of the fluid of the thoracic duct is much less firm than that of blood; and after a few days, if allowed to remain in a separate vessel, it passes almost entirely to the fluid state. Vauquelin regards it as unfinished fibrin, something between albumen and fibrin.

I once saw a young married woman whose urine contained very large coagula of chyle. She always dined at noon. In the evening the coagula were white; in the morning pale with pink streaks. After fasting twenty-four hours at my request, the coagula still appeared in the urine, extremely pale, and showing more pink streaks: and this is the more worthy of notice, as others, we see, have found chyle and lymph to grow reddish from abstinence (p. 124.) She had been some months in this way, was in very fair health, and had a great appetite, and perhaps some other general symptoms of diabetes; but there was no sugar in the urine. Notwithstanding the fluid discharged seemed to present as much coagulum as it did urine, the quantity of chyle proved on drying to be very minute, and from its looseness to have been extremely distended by the urine. As this was a state of disease, I draw no inference from the case respecting the time necessary for the change of chyle to blood. She would not allow me to take any blood from the arm for observation.

Similar cases have been published by Dr. Prout[b], and there may be several on record[c], but the only one besides of which I have read is quoted in Shenkius. "I saw," says the author whom he quotes, (in Castro Itri, Comitatus Sundorum,) "a young man, thirty years of age, who daily made a considerable quantity of urine, depositing a white substance like the curd of milk, sufficient to fill

[a] Dr. Prout, in Thomson's *Annals of Philosophy*. 1819. p. 275.

[b] *A Treatise on Gravel*, &c. 2d ed. 1825.

[c] See *Ephem.*, Dec. I. ann. i. obs. 89.

a common *pot de chambre*, besides the urine which was above it. He was in perfect health, not experiencing the slightest ill effect."[d]

Lymph from the hind extremities of a horse was found by Emmert to be white, with straw-coloured globules, to contain rather less albumen, to coagulate more imperfectly, and become less easily red on exposure to air, than the contents of the thoracic duct.[e]

According to the recent observations of Tiedemann and Gmelin, the chyle has no fibrin, so as scarcely to coagulate, nor any red particles, before it passes through the mesenteric glands; but immediately afterwards, and especially after it is mixed with the lymph of the spleen, — a fluid abounding with them and fibrin, — presents both, and still more copiously than the lymph of the extremities.

No fatty matter is discoverable in the lymph, nor indeed in the chyle if the animal fasts or takes food destitute of fat. The fatty matter is merely diffused through the chyle, and found even in the blood after butter has been eaten.

Ligature of the choledochus they found to augment the quantity of fibrin and red particles, and to diminish that of fatty matter in the chyle.

Dr. Prout has just published his belief in something like the opinion always entertained by Blumenbach, that the lymph, on account of being a highly animalised fluid, contributes greatly to the formation of blood. He goes farther than Blumenbach: yet perhaps Blumenbach's opinion may, in reality, though not

[d] *Observat. Med. rariores*, lib. iii. obs. 27. Dr. Charles Smith, of New Jersey, relates an example of ascites in a boy twelve years of age, where the fluid accumulated was of a chalky white colour, had pretty nearly the smell, taste, and appearance of milk, and threw up good cream after standing a night. Between seven and eight quarts of this were twice removed by tapping. *Philos. Mag.*, vol. ix. p. 168.

Shenkius is generally thought a credulous collector of incredible cases, and no doubt some of his histories as well as of his opinions are ridiculous. But careful modern observation discovers facts precisely similar to the greater number that he has collected. I might have doubted the history just related, more especially the good health of the patient, had not the case of the woman occurred to me. For example, he gives some instances of black urine made by persons in perfect health, and Dr. Marcet has published two such (*Transactions of the Medical and Chirurgical Society*, vol. xii.). Dr. Prout showed me a specimen of urine from one of these, and a specimen of blue urine, containing indigo.

[e] See also Vauquelin, *Annales de Chimie*, t. lxxxi. 181.

in words, amount to his.[f] Dr. Prout conceives that "*a sort of digestion is carried on in all parts of the body, to fit for absorption and future appropriation those matters that have been already assimilated.*" His chief reasons for this opinion are — 1. That, if the contents of the absorbents were really and wholly excrementitious, they would be rejected, and not poured into the blood. 2. If they are highly animalised, we have a reason for their admixture with the crude chyle before it is poured into the blood. 3. The gradual developement of the staminal principles of organised bodies, by repeated organising processes, agrees with the general truth of the operations of nature being never abrupt, but always slow and gradual; and matters already assimilated to the body must be better adapted for its immediate use than the imperfectly assimilated chyle. 4. Many animals can and do live for a considerable time on their own bodies.[g]

I agree entirely in these reasons, and consider it a great mistake to regard the lymph as a collection of excrementitious matters.

[f] Blumenbach's words are, — "Since the blood is a peculiar fluid, various means are required to assimilate the foreign fluids which pass to the thoracic duct. We must remember that a great part of the lymph has been derived from the substance of the viscera and other soft parts formerly secreted from the blood, and therefore already imbued with an animal nature." (*Inst. Physiol.*, §§ 446. 448.)—Raspail also says,—"Lymph is alcaline, and, in fact, to be considered as a variety of chyle or colourless blood." p. 455.

[g] *Bridgewater Treatise.*

Dr. Magendie denied the existence of lymphatics in nearly all birds, but has been amply refuted by Dr. Louth and many others. Birds have few lymphatic ganglia; and amphibia and fish still fewer (Blumenbach's *Manual of Comp. Anat.* translated, p. 174.); and invertebrate animals have no lymphatic vessels. These, therefore, are considered a refinement of organisation, and lymphatic ganglia a still greater. Professor Müller of Bonn has lately discovered in the lymphatic system, under the skin of the frog, and several other amphibia, *lymph-hearts,* pulsating regularly, though not simultaneously either with each other or the blood-heart, and destined to advance the lymph in its vessels. *Phil. Trans.* 1833.

A short account of the first discovery of the absorbent system may be acceptable at the close of this section.

Hippocrates knew that the nutritive portion of the contents of the alimentary canal was conveyed by certain vessels to the system. Erasistratus actually saw the lacteals containing chyle — *ἀρτηριας, γαλακτος πληρεις.* From Galen we learn

that they were known also to Herophilus. From the year 150 to 1622 no advance was made, except that in 1563 Eustachius discovered the thoracic duct, but he remained ignorant of its use. In 1622, Aselli in Italy saw the lacteals by chance, when demonstrating the recurrent nerves to some friends. Thinking they were nerves, he at first paid no attention to them; but, soon observing that they did not pursue the same course as the nerves, and "astonished at the novelty of the thing, he hesitated for some time in silence," while all the circumstances of the controversy and quarrels of anatomists passed before his view. He had by chance been reading Costæus on this subject the day before, and, in order to examine the matter further, he "took a sharp scalpel to cut one of those chords, but had scarcely struck it when," he continues, "I perceived a liquor white as milk, or rather like cream, to leap out. At this sight, I could not contain myself for joy, but, turning to the by-standers, Alexander Tadinus and the senator Septalius, I cried out Εὕρηκα! with Archimedes, and at the same time invited them to look at so rare and pleasing a spectacle, with the novelty of which they were much moved. But I was not long permitted to enjoy it, for the dog now expired, and, wonderful to tell, at the same instant the whole of that astonishing series and congeries of vessels, losing its brilliant whiteness, that fluid being gone, in our very hands and almost before our eyes, so evanished and disappeared, that hardly a vestige was left to my most diligent search." The next day he procured another dog, but could not discover the smallest white vessel. "I now," he says, with the same admirable *naïveté*, "began to be downcast in my mind, thinking to myself that what had been observed in the first dog must be ranked among those rare things which, according to Galen, are sometimes seen in anatomy." At length he recollected that the dog had been opened "athirst and unfed," and therefore opened a third, after feeding him "to satiety." "Every thing was now more manifest and brilliant than in the first case." He gave his whole attention to the subject, and was so diligent that not a week, or certainly not a month, passed without a living dissection of dogs, cats, lambs, hogs, and cows; and he even bought a horse, and opened it alive. "A living man, which Erasistratus and Herophilus of old did not fear to anatomise, I *confess* I did not open."

Notwithstanding this discovery of distinct chylous vessels, a large number of high authorities adhered firmly to the old opinion of Galen, that they were only mesenteric vessels. "There is not one among the doctors," we read in a letter of Thomas Bartholin, written at Montpellier, during his journey to Italy, "who acknowledges the lacteal veins, so wedded are they to the authority of Galen, for which they contend as *pro aris et focis*, and disregard the experiments of the moderns." Unluckily, he did not trace the lacteals to the left subclavian vein, but fancied they went to the liver, distributing the chyle through it for sanguification; this organ, according to the established doctrine, receiving the chyle from the mesenteric arteries and veins to convert it into blood.

In 1649, Pecquet, a physician at Dieppe, was removing the heart of a dog, when he noticed a quantity of white fluid pouring from the upper cava mixed with blood. He at first thought he had opened some strange abscess; and, after pressing first upon one part and then upon another, he compressed the mesentery, whose lacteals were full of chyle, when instantly a large quantity of this poured

from the superior cava. He traced the lacteals to the thoracic duct, and thus overthrew the doctrine of the liver being the great seat of hæmatosis.

Of course, there was as great an outcry against this innovation in doctrine, as there had been against the existence of lacteals, and even Harvey, who was now nearly eighty years of age, could not at once loosen himself from the bonds of early prejudice, and Thomas Bartholin, whose eyes had always been open to improvement in medicine, still thought that perhaps the finer parts of the chyle went by the new ducts to the chest, " while the grosser, needing a larger concoction, enter the liver."

About eighty years after the discovery of Asellius, Rudbeck, professor at Upsal, or Thomas Bartholin who was professor at Copenhagen and son of Caspar Bartholin, or Joliff, an English student, discovered the lymphatics.[h] Rudbeck says, he first happened to see them while examining the hemorrhoidal vessels of a dog, Jan. 27. 1651. He published in 1653. Bartholin, that he first chanced to see them while dissecting a dog, Dec. 15. 1651, but did not notice them particularly till Feb. 28. 1652. He published in 1653. As to Joliff, we only read in Glisson, that, at the beginning of June, 1652, going to Cambridge for his doctor's degree, he showed them to Glisson, who was then professor of medicine. Glisson published in 1654; Joliff never published, and probably had learnt the continental discovery while travelling. Bartholin is thought to have received a hint of Rudbeck's discovery. Haller gives the discovery to Rudbeck.

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[h] See an interesting history of these discoveries, by Dr. Meigs, *Philadelphia Journal*, 1825. No. 2. New series.

CHAP. X.

THE BLOOD.

THE fluid into which the chyle and lymph are converted, is blood. "The *blood* is" a slightly alcaline fluid, of a red colour; "of a peculiar odour; its taste is rather saline and nauseous; its temperature about 96° of Fahrenheit; it is glutinous to the touch; its specific gravity, though different in different individuals, may be generally estimated as 1050, water being 1000." Blood from arteries is florid, and from veins of a dark red which the translucence of the venous coats renders bluish when seen through them: and the specific gravity of the former is said by Dr. John Davy to be 1049, and of the latter 1051.[a] "When fresh drawn and received into a vessel, it exhibits the following appearances[b]:—

"At first, especially while still warm, it emits a vapour which," "if collected in a bell glass, forms drops resembling dew, of a *watery* nature, but affording a nidorous smell, which is most remarkable in the blood of carnivorous animals, is peculiar, and truly animal. Much of this watery liquor still remains united with the other parts of the blood, hereafter to be mentioned.

"In the mean time the blood" "begins to separate into two portions. A coagulum is first formed, from the surface of which exudes, as it were, a fluid of a yellowish slightly red colour, denominated *serum:* the more abundantly this exudes, the greater is the contraction of the glutinous coagulum, which has received the appellations of *crassamentum;* and, from some resemblance to the liver in colour and texture, of hepar sanguineum; of placenta; and, from the circumstance of its being surrounded by the serum, of insula."

Some have thought that heat is evolved during its coagula-

[a] *Journal of Science and Arts,* No. iv.

[b] "J. Martin Butt, *De spontanea sanguinis separatione.* Edin. 1760. 8vo. reprinted in Sandiford's *Thesaurus,* vol. ii. J. H. L. Bader, *Experimenta circa sanguinem.* Argent. 1788. 8vo."

tion[c]; others have denied this.[d] M. Raspail says that the temperature falls.[e]

" The crassamentum may, by agitation or repeated ablution, be easily separated into two constituent parts, — the *cruor*, which gave to the blood its purple colour — and the *fibrin*, which on washing is forsaken by the cruor, and called, from its greater solidity, the basis of the crassamentum.

" Besides the watery fluid first mentioned, these are the three constituents of the blood, viz. the *serum*, the *cruor*, and the *fibrin*, of each of which we shall presently treat more particularly. These, however, while perfectly recent, and in possession of their native heat, are intimately mixed, and form an equable, homogeneous fluid. Their relative proportion is astonishingly diversified, according to age, temperament, diet, and similar circumstances which constitute the peculiar health of each individual."

The quantity of blood in a well-formed adult is estimated by " Allen, Mullen, and Abildgaard, at little more than 8 pounds; by Harvey, at 9; Borelli, 20; Haller, 30; Riolan, 40; Hamberger, 80; and Keil, 100. The former are evidently nearer the truth." M. Le Canu says, that the quantity of its *water*, in a healthy person, varies from 853·135 to 778·625 in 1000 parts, and the medium quantity is greater in females and in the phlegmatic temperament: of its *albumen*, from 78·270 to 57·890, and has no relation to sex, age, or temperament; of its *fibrin* dry, from 1·360 to 2·236, is the greatest in the young or middle-aged, in the sanguine temperament, and in the inflammatory state; least in the phlegmatic temperament, the aged, and under congestion or hemorrhage: of its *globules*, from 148·450 to 68·349 — being the most remarkable variation — is greatest in males, the same between the ages of twenty and sixty, much greater in the sanguineous than the phlegmatic temperament, and much less after losses of blood, which do not affect the quantity of the albumen.[f]

[c] Dr. Gordon, *Annals of Philosophy*, vol. iv. Scudamore, *An Essay on the Blood*, 1824. p. 68. sqq.

[d] Dr. J. Davy, *Journal of Science and Arts*, No. iv. [e] l. c. p. 361.

[f] *Journal de Pharmacie*, Sept. and Oct. 1831. In various diseases, Dr. Clanny, of Sunderland, and Dr. Stevens, have found the salts of the blood exceedingly deficient. In fevers, the proportion of water increases as the disease advances, and that of the salts diminishes; and it is said that, in the latter stages, the exhibition of neutral salts is very beneficial, as recommended by Boerhaave, Huxham, &c. in the early part and middle of the last century, and Dr. Stevens at present in his *Observat. on the healthy and diseased Properties of the Blood*. London, 1832. Dr. Priestley remarked that different specimens of blood differed in their susceptibility of change of colour from air. *Ph. Tr.* 1776.

The *blood*, according to M. Le Canu, consists of the following constituents: —

	1st Analysis.	2d Analysis.
Water - - - - -	780·145	786·590
Fibrin - - - -	2·100	3·565
Albumen - - - -	65·090	69·415
Colouring matter - - -	133·000	119·626
Crystallisable fatty matter - -	2·430	4·300
Oily matter - - - -	1·310	2·270
Extractive matter soluble in alcohol and water - - - -	1·790	1·920
Albumen combined with soda - -	1·265	2·010
Chloruret of sodium and potassium, alkaline phosphate, sulphate, and sub-carbonates - - -	8·370	7·304
Subcarbonate of lime and magnesia, phosphates of lime, magnesia, and iron, peroxide of iron - -	2·100	1·414
Loss - - - -	2·400	2·586
	1000·000	1000·000

When blood, venous or arterial, is immediately placed in the vacuum of an air pump [g], or coagulates in the air [h], or is received from a vein into pure hydrogen [i], it emits a large quantity of carbonic acid gas. Professor Brande obtained two cubic inches from every ounce of blood; Sir C. Scudamore, less than half a cubic inch from six ounces.[k] The quantity is said to be much greater after a meal, and much less if the blood is buffy.

[g] Vogel, *Annales de Chimie*, t. xciii.

[h] Professor Brande, *Phil. Trans.* 1818. p. 181.

[i] Dr. Stevens, *London Medical Gazette*, 1834, No. xxviii. Mr. Hoffman, id. 1833, No. xxvi.

[k] *Phil. Trans.* 1820. p. 6. l. c. p. 107.

Blumenbach, found, in 1812, that a small portion of the purest air, infused into the jugular vein, excited palpitations, drowsiness, convulsions; and, if the quantity was a little increased, even death ensued. (*Medicin. Biblioth.* vol. i. p. 177.) Bichat observed the same effects in his experiments. (*Journal de Santé, &c. de Bordeaux*, t. ii. p. 61.) But Dr. Magendie stated, in 1809, to the Institute, that this assertion is incorrect. If air is injected rapidly, the animal screams and dies in a moment: but if slowly, he informs us that no inconvenience results, and that some animals bear the injection of enormous quantities without perishing. (*Précis Elémentaire de Physiologie.* 2d edition, 1825. t. ii. p. 433. sqq.) Dr. Blundel injected five drams into the femoral vein of a very

Chevreul, Lassaigne, and others discover a yellow colouring matter like that of the bile and urine. Dumas and Prevost and others discern something like urea, which M. Raspail suggests may be the effect of their experiments, as Woehler discovers urea to be a cyanite of ammonia, and capable of artificial production by passing cyanogen (bicarburet of nitrogen) through ammoniacal gas.

"The *serum* is a peculiar fluid, the chief cause of the viscidity of the blood, and easily separable by art into different constituent principles. If subjected to a temperature of 150° Fahr., a portion is converted into a white scissile substance, resembling boiled white of egg," and is in truth albumen; the watery portion which remains was termed serosity by Cullen, and contains various substances.

If mixed with six parts of cold water, serum does not coagulate by heat.

Under the influence of the galvanic pile, soda collects at the negative wire, and the albumen coagulates at the positive, on account, M. Raspail says, probably, of the decomposition of the salts and also of the water, and the consequent oxygenation of every thing at the positive pole, where the oxygen collects; and

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small dog, with only temporary inconvenience, and subsequently three drams of expired air even without much temporary disturbance. (*Med. Chir. Trans.* 1818, p. 65. sq.) Nysten has established that many gases soluble in the blood, as oxygen and and carbonic acid, may be thrown into the circulating system in very large quantity without serious inconvenience; while danger often ensues upon the introduction of those which are sparingly or not at all soluble in the blood. (Magendie, l. c.)

In the same way, if about 15 grains of bile are rapidly introduced into the crural vein of an animal, instant death occurs; but, if slowly, no inconvenience results. This quantity may be even rapidly injected into the vena portæ without injury, and so likewise may atmospheric air, probably because the extreme subdivision of the vessel acts like slowness of introduction, — causes the complete diffusion and dilution of the bile, and solution of the air, before it reaches the heart.

If warm water is introduced (an equal quantity of blood being first removed, to prevent over distension) mere debility ensues, proportionate to the quantity; but if oils, or mucilages, or an inert impalpable powder, are injected, life is at once destroyed by the obstruction of the minute ramifications of the pulmonary artery. (Magendie, *Journal de Physiologie,* t. i., and l. c. t. ii. p. 260.) Poisons act powerfully if injected into the veins; and, as will presently be mentioned, medicines, thus introduced, exert their specific powers on the different organs.

of the increase of temperature attending the decomposition of organised bodies.[l]

M. Le Canu gives the following analysis of serum: —

	1st Analysis.	2d Analysis.
Water - - - - -	906·00	901·00
Albumen - - - - -	78·00	81·20
Animal matter soluble in water and alcohol - - - -	1·69	2·05
Albumen combined with soda - -	2·00	2·55
Crystallisable fatty matter - -	1·20	2·10
Oily matter - - - - -	1·00	1·30
Muco-extractive matter - -	—	—
Extractive matter soluble in alcohol and acetate of soda - - -	—	—
Hydrochlorate of soda and potash -	6·00	5·32
Sub-carbonate and phosphate of soda and sulphate of potass - - -	2·10	2·00
Phosphate of lime, magnesia, and iron, with sub-carbonate of lime and magnesia	0·91	0·87
Loss - - - - - -	1·00	1·61
	1000·00	1000·00

The *cruor* consists of globules; and Mr. Hewson asserts that they have a nucleus and an enveloping coloured portion.[m] The nucleus is said to be colourless: perhaps about $\frac{1}{5000}$ of an inch in diameter, and the whole globule nearly one fourth larger.[n] M. Raspail says, that, though the form and dimensions of the particles are different in different species, and nearly the same in the same individual, they still vary within very narrow limits in individuals, and the dimensions in even the same drop of blood, especially if not examined immediately that the blood is taken from the vessels. In man, he says, they are from $\frac{1}{100}$ to $\frac{1}{200}$ of a millimètre, flat and circular. MM. Prevost and Dumas believe[o] that the internal portion is spherical, but the outer or vesicular, as Hewson noticed[p], flattened. The inner part, according to these

[l] l. c. 202.

[m] *Experimental Inquiries*, part. 3. p. 16. 1777.

[n] On these measurements consult *Phil. Trans.* 1818. Dr. Young's *Medical Literature*, p. 571. sqq. Prevost and Dumas, *Annales de Chimie*, Nov. 1821. Hodgkin and Lister, *Ph. Mag.* Aug. 1827. Particularly M. Raspail.

[o] l. c. Hodgkin and Lister find no nucleus.

[p] l. c. p. 8. sq. Hewson says, that dilution with water, or a change towards

enquirers, rolls in the outer, and, in the frog's web and bat's wing, at least, the whole particle is carried, steadily balanced, in the current of blood, sometimes flat, sometimes oblique, sometimes gently turning upon itself, and lengthening if driven into a vessel of diameter hardly sufficient for its admission; the old assertion of Reichel [q] being thus corroborated. Kalk, Treviranus, and others have noticed a rotatory motion of the entire particles, each at a distance from the other; and Professor Schultz of Berlin has confirmed their observations. But M. Raspail considers these motions as accidental and mechanical results, such as have deceived so many microscopic investigators. Mr. Bauer says he has discovered a third set of smaller colourless globules in the blood, $\frac{1}{2800}$ of an inch in diameter, which appear to belong to the fibrin, and are accordingly denominated lymph globules; and it is thought probable that the central globule of the red particles is the same, and thus really fibrin. Colourless globules gradually form also in serum. [r] The globules of pus also are asserted to form gradually, and it to be originally an homogeneous fluid.

The globules of the blood, independent of their covering of red substance, M. Raspail regards as mere particles of albumen not dissolved in the serum, and, after proving their albuminous nature, shows how albumen dissolved in an excess of concentrated hydrochloric acid forms minute, spherical, equal globules, in proportion as the decanted acid *spontaneously* evaporates, scarcely distinguishable from the globules of the blood. One takes breath while reading M. Raspail, after the strange and varying statements of so many experimenters, especially of those who use microscopes.

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putrefaction, makes the vesicles globular, and that farther putrefaction breaks them down. The effects of dilution with water are, according to Raspail, extension, sometimes spherical, sometimes elliptic, and at length complete solution.

[q] G. Chr. Reichel, *De sanguine ejusque motu experimenta.* Lips. 1767. p. 27. fig. 3. g. g.

[r] *Phil. Trans.* 1819. p. 2. sq. The globules of milk, healthy pus, and chyle, in different animals, are said by Prevost and Dumas to be of the same form and dimensions: and likewise those of the muscular fibre, and of albumen, when coagulated, for particles, we are told, are not previously seen in it. But Dr. Hodgkin finds the particles of pus to be quite irregular in size and figure, and those of milk, though globules, to be some twice, some only one tenth, the size of the particles of the blood. *Phil. Mag.* Aug. 1827, and translation of Dr. Edward's work. I shall refer to M. Raspail in the proper place.

If arterial blood is exposed to ammoniacal gas, it becomes of a cherry red; if to gaseous oxide of carbon, the deutoxide of azote, or carburetted hydrogen, of a violet red; if to carbonic acid, though covered by two inches depth of serum[s], azote, hydrogen, or protoxide of azote, of a brown red; if to arseniuretted or sulphuretted hydrogen, of a deep violet inclining to a greenish brown; if to hydrochloric gas, of a chestnut brown; if to sulphureous gas, of a blackish brown; and if to chlorine, of a blackish brown inclining to a greenish white.[t] These gases are of course partly absorbed or decomposed. The dark colour produced in arterial blood by carbonic acid or azotic gas takes place if blood is placed in vacuo[u], though less rapidly and deeply than if exposed to hydrogen gas, and in vacuo, though covered by two inches and a half of serum.[x] Arterial blood extravasated or included between two ligatures in an artery[y], nay, left in contact with oxygen, gradually acquires the same dark colour, and no oxygen will afterwards render it scarlet. Acids, if stronger than just enough to neutralise a weak salt, and alcalies, darken arterial blood. If deprived of all saline matter by washing, the reddest clot of blood becomes black, and will not grow florid by oxygen: whereas if saline matter is added, it becomes florid, even in an atmosphere of carbonic acid.[z]

Venous blood acquires a florid colour by exposure to oxygen or atmospheric air (and it does so even when covered by a bladder, provided this is moistened[a]), carbonic acid gas is formed, and an equal volume of oxygen gas disappears, and this the more if the temperature is high.[b] If exposed to nitrous oxide, it becomes of a brighter purple, and much of the gas is absorbed; carbonic acid gas renders it darker, and is a little absorbed: nitrogen and hydrogen have the same effect. Electricity blackens the blood, and, according to Dr. Stevens, the poison of the rattlesnake, and other poisons, though floating only in the air. Putrefaction makes the blood dark. Alcaline and some other neutral

[s] Dr. Priestley, *Ph. Tr.* 1776.

[t] Raspail, l. c. p. 361.

[u] Beccaria, who experimented at the request of Cigna. *Misc. Taur.* t. i.

[x] Dr. Priestley.

[y] Hunter, *On the Blood*, p. 65. sq.

[z] Dr. Stevens.

[a] A layer of serum or milk does not prevent this change of colour, while a layer of water, saliva, and every other animal fluid, or oil, does. Dr. Priestley.

[b] Dr. Stevens.

salts, make venous blood florid[c]; and this, if added in considerable quantities, even when the blood is exposed, not to oxygen or air, but to a blackening gas.

Dr. Stevens seems to have proved that the colouring matter of the blood is really black, and acquires redness only by the action of the salts upon the hematosine; and that venous blood is of a dark red through the presence of carbonic acid, and but for the salts would be black. If blood is black from want of salts, very little of them will make it florid; if it is black from the presence of carbonic acid, azote, &c., the quantity of salts requisite will be proportionate to the quantity of the blackening agent. Oxygen indirectly renders blood florid, by removing the carbonic acid gas, and thus allowing the salts of the serum to brighten it; for if these are washed away, we see that oxygen has no effect, and we see that in proportion to the disappearance of oxygen is carbonic acid evolved. The same interchange of carbonic acid takes place in hydrogen, and the blood remains black; but then hydrogen blackens blood as well as carbonic acid. It is possible that oxygen may have the property of making blood florid, just as hydrogen, nitrogen, carbonic acid, &c. have to make it dark. But if it have, still it does not make the blood florid unless salts be present, and carbonic acid always appears; and when blood is darkened by putrefaction, so that air will not make it florid, the addition of most neutral salts instantly brightens it. Such are the statements of Dr. Stevens.

Berzelius finds the colouring particles only concerned in these changes. Prevost and Dumas found more fibrin and red particles in arterial than in venous blood; and the venous must contain a larger quantity of carbonic acid, and the arterial an abundance of oxygen: Macaire and Marcet, on *ultimate* analysis, find about five per cent more oxygen in arterial, and five per cent more carbon in venous, blood.[d]

It is in the red covering of the particles, or hematosine, as the colouring matter is now called, that the iron of the blood exists. Berzelius informs us that serum, although able to dissolve a small portion of the oxides, not indeed of the phosphates, of iron, does not acquire a red colour by their addition, and that he has never discovered iron nor lime in the entire blood, although both are so abundant in its ashes. He concludes that

[c] Boyle, *Ph. Tr.* 1666–7. Haller, *El. Phys.* lib. v. 1757. Hewson, *Ph. Tr.* 1770. Dr. Priestley, *Ph. Tr.* 1776. He adds that the urine makes blood florid because of its saline nature. Dr. Stevens, more minutely, l. c. 1832.

[d] *Mém. de la Soc. Phys. et d'Hist. Nat. de Genève,* t. v. p. 400.

the blood contains the *elements* of phosphate of iron and of lime, and of carbonate of lime, and also of phosphate of magnesia, united in a manner different from their combination in the salts. M. Raspail, seven years ago, showed that certain coagulable substances will protect a metal from the strongest re-agent — that a mixture of oil and the salts of iron will afford no signs of the metal till some days after it has been placed in acidulated ferrochyazate of potass. Rose obtained the same result on mixing albumen or gelatine with peroxide of iron. But Dr. Engelhart has shown iron to exist in blood, by the usual liquid tests, after passing a stream of chlorine through a solution of red particles.[e]

"The last constituent principle of the blood to be noticed, is the plastic *lymph*, formerly confounded with the serum. This has been called the basis of the crassamentum, the glutinous part, the fibre or fibrous matter of the blood." It is now termed *fibrin*.

"It is properly denominated plastic, because it affords the chief materials from which the similar parts, especially the muscles, are immediately produced; nourishes the body throughout life; repairs wounds and fractures in an extraordinary manner; fills up the areæ of large blood-vessels when divided[f]; and forms those concretions which accompany inflammations[g], and that remarkable deciduous membrane found in the recently impregnated uterus for the attachment of the ovum."

We will now consider the coagulation of the fibrin more minutely.

Blood coagulates when it has escaped from the body, whether warm or cold, in the air or in vacuo, diluted within certain limits or undiluted, at rest or in motion. Within the vessels, rest, which causes a cessation of intercourse between the motionless portion and the general mass, always disposes it to coagulate. Yet its

[e] *Edinburgh Medical and Surgical Journal,* Jan. 1827. Engelhart's Essay obtained the prize at Göttingen in 1825.

[f] "T. F. D. Jones, *On the process employed by nature in suppressing the hemorrhage from divided* &c. *arteries.* London. 1805. 8vo. Translated into German, and supplied with notes by G. Spangenberg. Hanov. 1813. 8vo."

[g] "Such are those *spurious membranes* found exuded on the surface of inflamed viscera, *v. c.* those cellular connections between the lungs and pleura after peripneumony, and the tubes observed within the bronchia after croup; such also are those artificial ones, called, from their inventor, Ruyschian, and made by stirring fresh blood about with a stick." Although they are fibrinous, they contain a fluid in their cells that is albuminous.

coagulation, after escape from the body, is said to be accelerated by motion, a high temperature, and a vessel calculated to preserve its temperature, by a vacuum, and by the stream from the blood-vessel being slow, and *vice versâ:* in short, by every circumstance which favours the escape of carbonic acid gas, and to be proportioned to the quantity of carbonic acid gas evolved; this being evolved during the coagulation, and ceasing to escape when the coagulation is complete.[h] Galvanism and oxygen gas raise its temperature and hasten coagulation, while carbonic acid gas, azote, and hydrogen, have the opposite effects. Dilute mineral acids coagulate the blood: alcalies and their carbonates retain it fluid.

The coagulation of the blood is ascribed by J. Hunter to its life[i]; by Mr. Thackrah[k], on the contrary, to its death, as the separation of a portion from the mass, by escape from a vessel, is likely to kill it if alive; as every change likely to impair life promotes coagulation, for example, debility, fainting; and as blood frozen, and therefore likely to be killed if alive, and again thawed, instantly coagulates. But the coagulation appears, in most instances, if Sir C. Scudamore's experiments be accurate, though others have not found the same results[l], attributable merely to the escape of carbonic acid; and as coagulated blood or fibrin (and the coagulated part of effused blood is fibrin) becomes vascular, one can hardly, if the fluid is alive, regard a coagulum as necessarily dead.

Large quantities of blood are found fluid in every dead body, showing that simple loss of vitality is not sufficient to cause coagulation. Indeed, the blood of the various parts of the heart and vessels is found, most frequently, in opposite states, fluid in one part, coagulated in another; yet it is all equally dead. From all these contradictory circumstances, I regard the coagulation of the blood as quite unconnected with its vitality or lifelessness, and as entirely a chemical result. That it, however, is influenced by the vital properties of the containing vessels is possible, but these may operate upon the blood, in this respect, as a mere chemical compound; and even, if it be alive, and they influence its life, still the influence, as far as respects coagulation, may in effect be chemical.

[h] Scudamore, l. c.

[i] *A Treatise on the Blood*, &c.

[k] *An Enquiry into the Nature and Property of Blood.* By C. Turner Thackrah. London, 1819.

[l] Dr. Turner, *Elements of Chemistry*, 1827. p. 638.

The blood generally coagulates in the living body on escaping from its vessels, and even in its vessels if its motion be prevented by ligatures; and when it does not, its subsequent escape from the body almost always produces instant coagulation.[m] It almost always coagulates also in the vessels running through healthy parts to others in a state of mortification, and in large vessels adjoining a pulmonary abscess; in which cases, the final cause or purpose — prevention of hæmorrhage, is evident. The efficient cause, however, in all these examples, is unknown. In all, the blood is still in contact with living parts: in the last two, it is perhaps not at rest till it coagulates. J. Hunter, after mentioning that in a mortification of the foot and leg he found the crural and iliac arteries completely filled with strongly coagulated blood, adds, that this could not have arisen from rest, because the same thing ought then to happen in amputation, or in any case where the larger vessels are tied up.[n] Besides, coagulation after extravasation, or when a quantity is included in a vessel between two ligatures, is not an invariable occurrence.

These facts, in addition to those stated above, show that fluidity or coagulation is not dependent on the simple presence or absence of vitality. Whatever connection coagulation out of the body may have with the escape of carbonic acid gas, there is no proof of it in the case of internal coagulation.

Some have imagined the globules to be not only endowed, through vitality, with spontaneous motion, but with repulsion, which ceases with life, and thus by their death to run together and produce the phenomenon of coagulation. But M. Raspail contends, as we have noticed, that such spontaneous motion is a microscopic accident, and that, so far from being organised, they are merely minute precipitations of albumen; and he shows that, when the blood coagulates, the globules are seen under the microscope enveloped in the coagulum, which, therefore, cannot be a mere union of them. He asserts, that fibrin and albumen are identical, and that the fibrin is preserved liquid by the alcalies of the blood, — soda and ammonia; which, if they become saturated by the carbonic acid of the atmosphere and that which forms in blood when exposed to the air, can no longer act as a solvent,

[m] J. Hunter mentions the coagulation of blood let out from the tunica vaginalis, in which it had lain fluid sixty-five days after a wound. *On the Blood*, p. 25.

[n] l. c. p. 23.

and the fibrin accordingly coagulates.[o] The escape of the ammonia and of a certain quantity of the water of the blood augments this effect, and blood coagulates the sooner in proportion as it is less watery. Coagulation within the blood-vessels he regards as produced by the escape of some of the water of the blood through the coats of the vessels. Some glutinous saps, as that of the *chara hispida* (stone-wort), coagulate, like the blood, chyle, and milk, and they all have albumen in the state of globular precipitation and solution, have the same salts, and their coagulation ceases when the solvent of the albumen is saturated, evaporated, or weakened. In sap, the solvent is acetic acid.[p]

The fibrin may be separated from the red particles by agitation, and in inflammatory diseases it very frequently separates when drawn. Some conceive, that in health the cruor has a greater affinity for fibrin than for the serum, and therefore unites with it in preference. But to suppose any affinity of the red particles for either the fibrin or the serum is erroneous. Leeuwenhoek and Hartsoeker long since proved that serum merely suspends them; for if, when separated, they are triturated in some serum, part of them is taken up and the serum assumes a red colour; but, if the fluid is allowed to settle in a cylindrical glass, they slowly precipitate themselves to the bottom, and the serum above becomes clear as before. When blood is drawn, the serum easily separates on the coagulation of the fibrin. But the fibrin coagulates before the colouring particles have time to fall to the bottom, and entangling them acquires a red colour, forming the crassamentum: if, however, the fibrin coagulates slowly and is thinner[q], as in the phlogistic diathesis and pregnancy, the greater specific gravity of the cruor detaches it very considerably from the fibrin, which remains colourless above, constituting what is called the inflammatory coat, crust, or buff. Berzelius even believes the fibrin to be in a state of solution in the serum, while the cruor is simply suspended in this solution. In the phlogistic diathesis both the fibrin and the serum are more abundant, and the blood lighter.[r]

Thinness of the blood and a disposition to slow coagulation

[o] Dr. Prout also says, " A portion of soda is requisite to preserve the weak alcaline condition, essential to the fluidity of the blood." l. c. p. 496.

[p] l. c. p. 372. sqq.

[q] Hewson, *Experimental Enquiries into the Blood and the Lymphatic System*, P. 1. p. 45. sq.

[r] Scudamore, l. c.

generally co-exist. But the rapidity of the stream greatly affects the rate of coagulation, so that one portion of the same blood coagulates slowly that is drawn quickly, and another quickly that is drawn slowly.

The appearance of the buffy coat does not arise from the slow coagulation, though increased by it; because, of two portions of the same blood, one has afforded no buffy coat, although it remained fluid at least ten minutes after the buffy coat began to be formed on the other[s], proving, too, if the buffy coat arise from thinness of the fibrin, as appears from Mr. Hewson's experiments, the red particles continuing of their usual weight, that slow coagulation is not altogether dependent on mere thinness of the blood, though generally connected and proportional with it. Yet rapid coagulation, by means of a slow stream when the blood is thin, may prevent the buffy coat, by not allowing time for the difference in the weight of the fibrin and red particles to have effect. Stirring such blood, or receiving it into a shallow vessel, has the same consequence, and the slower the coagulation of thin blood, occasioned, for instance, by rapid bleeding, the greater will be the buffy coat.

If one portion of the same blood is received into a shallow, and another into a deep vessel, the coagulum of the former is looser and spongy, and the quantity of separated serum less.

The different cups of blood drawn in an inflammatory disease may vary as to the buffy coat, according to accidental variations in the stream; but generally it is the first cup that abounds in buff, and the last frequently has none. This occurs when there is no difference in the stream.[t] Therefore, if the buff arise from thinness of the fibrin, we must conclude with Hewson[u] that its qualities may be changed even during bleeding. Sir C. Scudamore finds much more fibrin in buffy blood; and, consequently, that not merely the thinness, as Hewson observed, but the quantity, of fibrin may vary during the flow of blood.[x]

The greater the strength of the patient and the intensity of the inflammation, the firmer is the coagulum of fibrin and the more cupped its appearance.

Sir C. Scudamore did not find a buffy coat in blood drawn immediately after violent exercise.

[s] Hewson, l. c. p. 90.
[t] l. c. p. 52. sqq.
[u] l. c. p. 56. sqq.
[x] l. c. p. 96.

Fibrin is inodorous and tasteless, whitish, insoluble in alcohol and acids, slightly soluble in boiling water long applied; coagulates, as already said, when separated from the body; dries hard, brittle, and semitransparent.

Albumen is inodorous, tasteless, colourless, soluble in water, and coagulates by a temperature of 150°, by pure potass, the mineral acids, tannin, and many metallic salts, especially by bichloride of mercury, and by prussiate of potass if a little dilute acid is previously mixed with it. Acetic and some other acids dissolve it, and even render it to a certain point soluble in alcohol and boiling water, according to M. Raspail; who also, under the microscope, discovers albumen to consist of two substances, the one an insoluble and organised tissue, the other a fluid contained in the cells of this.[y] The insoluble portion, however, forms gradually only, and in fresh eggs can scarcely be distinguished from the soluble; just as is the case with the woody fibres of vegetables, that gradually form from a gum. Dr. Wollaston stated, that the soda of albumen prevents it from all coagulating by heat, and the addition of an acid, by neutralizing the alcali, renders it completely coagulable.[z] Raspail says[a], "alcaline solutions, even alcaline carbonates," prevent heat from coagulating albumen. Mr. Brande thinks it liquid only through alcali.[b]

Chemists all allow that fibrin, albumen, and colouring matter afford, on decomposition, the same saline and gaseous products. Berzelius views them all three as modifications of the same substance. Albumen contains a greater proportion of oxygen than fibrin, and has sulphur for a constituent part, which, however, cannot be detected while the albumen is entire, any more than the iron while the cruor is entire. The chief differences between the colouring matter and fibrin are, colour; the spontaneous coagulation of fibrin at all temperatures, while the colouring matter may be dried without losing its solubility in water and becomes insoluble only at a certain temperature; and the peculiarity in the latter of not diminishing in volume like fibrin during exsiccation. According to most chemists, albumen is intermediate between the two; and its only character of distinction from fibrin is, that it does not coagulate spontaneously, but requires a high temperature or some chemical agent. M. Raspail maintains that albumen and fibrin are identical; and that the slight differences

[y] *Hewson,* l. c. p. 191. sqq.
[z] *Ph. Tr.* 1811.
[a] *Hewson,* l. c. p. 198.
[b] *Ph. Tr.* 1809.

between the two are referable to the natural and adventitious salts of albumen, varying according to the organs from which it is obtained. The following results are given[c] by Gay-Lussac and Thénard, in regard to them and gelatine: —

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Gelatine - - -	47·881	7·924	27·207	16·998
Albumen - - -	52·883	7·540	23·872	15·705
Fibrin - - -	53·360	7·021	12·685	19·934

Besides which, they, as well as the colouring matter of the blood, contain a very minute portion of the earthy phosphates.

We formerly saw that Dr. Prout is of opinion, at present, that when oxygen and hydrogen exist united, it is in the form of actual water, as an essential constituent of unazotised vegetable bodies, one atom of carbon being united with one of water. Now M. Raspail makes it highly probable, that the nitrogen of vegetable gluten, of albumen, fibrin, gelatine, and other animal matters, exists combined with another portion of hydrogen in the form of ammonia, which again is combined, as a base, with some acid, making an ammoniacal salt. The remaining small quantity of the hydrogen, not united with oxygen into water, is united with carbon into carburetted hydrogen; so that substances called azotised are really not azotised. He shows that the numbers given by Thénard are such as will give so much water, ammonia, and carburetted hydrogen, with pure carbon. Vegetable substances have been hitherto considered as ternary compounds of oxygen, hydrogen, and carbon: animal substances, and vegetable gluten, quaternary compounds of oxygen, hydrogen, carbon, and nitrogen; for most animal substances usually afford nitrogen, and but few vegetable substances excepting gluten. In M. Raspail's views, organised bodies consist of water, ammonia, carbon, and salts. And here I must remark, that the alcaline, earthy, and other substances, found in minute quantities in animal and vegetable compounds, and which have usually been regarded as foreign and unimportant, are, with great reason, considered by Dr. Prout as integrants in the compounds, and chiefly productive of the striking differences observed in substances having otherwise the same essential composition. The importance of minute quantities of matter is shown, he remarks, in the experiments of Sir John Herschel, who found that a power not less

[c] *Recherches Physico-Chimiques*, t. ii.

than 50,000 times greater than the power of gravity, is constantly generated (under the galvanic influence, for example) by the alloy of mercury with a millionth part of its weight of sodium. Dr. Prout regards these incidental particles as in a state of mutual repulsion, because, instead of being equally diffused as they are, they would otherwise be collected into a mass or crystal.[d]

I may mention, that Dr. Prout says perhaps it may be stated as a general law, that no substance, entering into the composition of a living plant or animal, is so pure as to be capable of assuming a regularly crystallised form. Instead, therefore, of being defined by straight lines and angles, all solid organised substances are more or less rounded, and their intimate structure is any thing but crystallised. The composition of organised fluids is equally heterogeneous; and, though the basis of nearly every one of such fluids is water, many of them contain a variety of other matters.

M. Raspail remarks further, that the constituents of organic solids or fluids are not combined in definite proportions, like those of inanimate bodies, but are ever variable, so that the varieties of each compound are infinite.[e]

[d] *Bridgewater Treatise*, p. 425. sq.

[e] l. c. p. 78. sq.

"The idea of succession and developement leads to the conclusion, that, if the products are examined at a certain period, they will be found chemically more or less heterogeneous, and more or less mixed. In some, the combined water and carbon are not yet combined with a base, or at the utmost are mixed with one; then we have gum. In others, the carbon is mixed with hydrogen only, or at the utmost with a small quantity of water: that this may assume the characters of a substance fit for organisation, it must obtain sufficient oxygen aspired by the cellular apparatus, to transform all the hydrogen into water; till then the compound was an oil, or resin. Finally, the carbonic acid absorbed, instead of uniting with a quantity of hydrogen sufficient to convert the oxygen of the acid into water, may unite with a fresh quantity of water or other substances, even with a quantity of salts insufficient to neutralise them, and then, becoming an acid of a new form, it will serve as a brute unorganised body for the elaboration or the decomposition of the salts which are necessary for the developement of the tissues."

Most cold-blooded animals, as fishes and the amphibia, have a much smaller proportion of blood and fewer blood-vessels than those with warm blood, though a much greater number of colourless vessels arising from the arteries. In an experiment which Blumenbach made on this subject, he "obtained from twenty-

four adult water-newts (lacerta palustris), which had been just caught, and weighed each an ounce and a half, ℈ iijss. of blood. The proportion to the weight of the body was as $2\frac{1}{2}$ to 36, while in healthy adult men it is as 1 to 5." (*Compar. Anatomy,* ch. xii. ed. i. p. 245. Translated by Mr. Lawrence.)

The blood of different brutes coagulates in different times. Mr. Thackrah imagines the rapidity to be inversely as the strength and size. Thus, while in health, human blood coagulates in from 3 or 4 to 7 minutes, that of the

Horse, in from	2	to	15
Ox,	2	to	10
Dog,	$\frac{1}{2}$	to	3
Sheep, hog, rabbit	$\frac{1}{2}$	to	$1\frac{1}{2}$
Lamb,	$\frac{1}{2}$	to	1
Fowls,	$\frac{1}{2}$	to	$1\frac{1}{2}$

Mice, in a moment.

Fish, according to Hunter (l. c. p. 211.), also in a moment.

The blood of brutes has the same general character as our own, and Rouelle obtained the same ingredients, though in different proportions, from the blood of a great variety of them. Berzelius finds a larger proportion of nitrogen in that of the ox, and analogy would lead us to suppose there is a peculiarity in the blood of every species. Muscles look pretty much alike in various animals, yet when cooked they disclose the greatest diversities. Transfusion, or pouring the blood of one system into another, satisfies us, that the blood, whether arterial or venous, of one *individual,* agrees well enough with another of the same species; but some late experiments of Dr. Leacock (*Medico-Chirurgical Journal,* 1817, p. 276.), and subsequently of Dr. James Blundel (*Medico-Chirurgical Transactions,* 1818), render it unlikely, contrary to the opinion of former experimentalists, that the blood of one *species* suits the system of another. Dr. Young found the large outer globules of the skate to be somewhat almond-shaped, and Hewson found them of different shapes in different animals, and Rudolphi observed them to be more or less oval in the common fowl and many amphibia. (*Grundriss der Physiologie,* 159.) MM. Prevost and Dumas have noticed, in their microscopic experiments, a great difference in the blood of different animals as to the globules, and in this way explain the impossibility of transfusing the blood of some animals to others without danger to life. They assert that the quantity of the particles is proportionate to the temperature of the animal, and that, consequently, most exist in the blood of birds: that the size and shape also vary, although the size of the central portion is the same in animals in which they are spherical, and is about $\frac{1}{7500}$ of an inch in diameter: and that the shape of the external part is circular in the mammalia, and elliptical in birds (M. Raspail says, in oviparous quadrupeds also) and cold-blooded animals, thus confirming and generalising the observations of others, for Hewson observed the difference of their size in different animals, and that this bore no relation to the difference in the size of the animal (l. c. part iii. p. 10. sqq.): and they find the shape of the central portion correspondent with that of the external,—spherical when the latter is circular, oval when elliptical. They assert that, if the blood of two animals of different species, the blood of one of which was transfused into the other, differed in the size only of the globules,

temporary restoration of energy took place; but that, if it differed in their shape, convulsions and death were the result. They also find a larger proportion of fibrin and red globules in warm than in cold blooded animals, and a larger in the former according to the height of the temperature — (of 10,000 parts by weight; in pigeons, 1557; man, 1292; frogs, 690); — a smaller, also, accordingly as animals are bled; it thus appearing that bleeding promotes the absorption of watery fluid. (*Annales de Chimie*, t. xviii. xxiii. 1821 and 1823.) The colour of the particles differs in different animals: hence red and white blooded animals.

Hewson (l. c. part iii. p. 39.) saw the red particles of the blood of the fœtal chicken and viper larger than those of the adult animal: and Prevost and Dumas have observed the red particles of the fœtal goat to be as large again as those of the adult; and those of the chicken to be circular, till about the sixth day, when some elliptic ones are first seen; and on the ninth, from their progressive multiplication, none but elliptic ones can be detected. (*Annales des Sciences Naturelles*, 1824, 1825.)

In the frog the particles are $\frac{1}{40}$, and in the salamander even $\frac{1}{30}$, of a millimètre, — the largest known.

The blood of invertebral animals is colourless, but has not been analysed.

The temperature of the blood, in general, varies with that of the animal.

The sap of vegetables is different, accordingly as it is examined when ascending from the roots, or descending again. The ascending sap is chiefly a watery solution of alcaline, earthy, and even metallic matters, and the proportion of water is very large, on account of the little solubility of many of these; the descending, or returning sap, is the same concentrated by exhalation from the leaves, and loaded with carbon, obtained in them from the atmosphere.

The former may be compared to chyle, the latter to blood; and this is more and more elaborated and converted into various organic substances, so as to be saccharine, fecular, glutinous or milky, oily, resinous, gum-resinous, and oleo-glutinous.

All vegetable principles are divided by Dr. Prout (*Bridgewater Treatise*, p. 454.) into three great classes—those in which oxygen and hydrogen are combined in the proportions which form water — the saccharine; those in which hydrogen, or rather carbon and hydrogen, predominate — the oily; and those in which oxygen predominates — the acid. Some contain azote also, like animal principles, from which, indeed, it is never absent; and some, weak alcaline powers, as quinine, morphine, &c.

About forty years after the discovery of the circulation of the blood, *transfusion* was practised upon brutes, and at length upon the human subject, though some contend that the operation was known to the ancients. Experiments were made upon the effects of injecting medicated liquids into the blood, first by Wahrendorf, in Germany. It was ascertained that they exert their specific powers exactly as when swallowed, — cathartics, *v. c.* purging, and emetics emptying the stomach. Among other liquids, Dr. Christopher Wren proposed that blood should be injected, and Dr. Lower first put this into practice. It

was found that if an animal was drained of its blood, and lay faint and almost lifeless, and the blood of another was transfused into its circulating system, it soon revived, stood up, and presently ran about as before, apparently none the worse for the operation. If too much was poured in, the animal became drowsy, breathed with difficulty, and died of plethora. An idea of curing diseases in this way, by substituting the blood of the healthy for that of the diseased, was immediately entertained when the possibility of the operation was proved.

But the first case of human transfusion proved fatal, and the unfortunate results of some careless trials caused the Pope and the King of France to prohibit the practice.

The extravagant hopes of curing diseases and restoring youth, at first entertained in France, were disappointed, and the operation fell into complete neglect, notwithstanding that Denys, in France, was declared to have made a fool clever by a supply of lamb's blood; a Mr. Cox, in England, to have cured an old mongrel of the mange with the blood of a young spaniel; and a M. Gayant to have made a blind old dog frisk with juvenile bound, which before could hardly stir; till Dr. Leacock brought it again into notice a few years ago, and Dr. James Blundel prosecuted this gentleman's researches. Dr. James Blundel conceived it might be rationally expected to be of benefit in cases of dangerous hæmorrhage, and he soon proved it to be void of danger in the human subject, if properly performed. Many women, who would probably otherwise have perished from uterine hæmorrhage, now owe their lives to his disinterested zeal in establishing the practice.

I should think it applicable to many cases of exhaustion, besides those arising from hæmorrhage. The original history of transfusion will be found in the early numbers of the *Philosophical Transactions:* the successful cases of its employment as a remedy, in the late English journals. The double pump employed for emptying the stomach, or a common syringe, capable of holding four or six ounces, answers very well. But Dr. Blundel at present, when he has able assistants, sometimes receives the blood from the blood-vessel into a funnel, the tube of which is very long, and inserted in the vein of the subject supplied, so that the blood enters by its gravity only.

Very lately salts of potass and soda, dissolved in various quantities of water, have been injected into the veins of persons exhausted by the Asiatic epidemic, improperly called Cholera. The effect is often astonishing. The patient, apparently almost lifeless, often revives, sits up, speaks, and takes nourishment. The improvement is transient, but frequently recurs on repeating the injection, and sometimes life has probably been saved by the measure. Many pints of saline fluid have thus sometimes been introduced in a few hours. Occasionally, oppression of the head has been induced; but generally a greatly increased discharge of fluid from the alimentary canal occurred.

CHAP. XI.

THE MOTION OF THE BLOOD.

" The blood, to whose great and multifarious importance in the system we have slightly alluded, is conveyed, with a few exceptions, into the most internal and extreme recesses. This is proved by the minute injection of the vessels, and by the well-known fact of blood issuing from almost every part on the smallest scratch.

" This red fluid does not, like an Euripus, ebb and flow in the same vessels, as the ancients imagined, but pursues a circular course ; so that, being propelled from the heart into the arteries, it is distributed throughout the body, and returns again to the heart through the veins.[a]

" We shall, therefore, say something at present of the *vessels* which contain the blood, and afterwards of the *powers* by which they propel and receive it.

" The vessels which receive the blood from the heart, and distribute it throughout the body, are termed *arteries*.

" These are, upon the whole, less capacious than the veins ; but in adult, and advanced age especially, of a texture far more solid and compact, very elastic and strong.

" The arteries consist of three *coats*[b] :—

" I. The exterior, called, by Haller, the TUNICA CELLULOSA PROPRIA ; by others, the nervous, cartilaginous, tendinous, &c. It is composed of condensed cellular membrane, externally more lax, internally more and more compact : blood-vessels are seen

[a] " Among warm-blooded animals, the egg, especially at the fourth and fifth day of incubation, if placed under a simple microscope, such as the Lyonetian, is most adapted for the demonstration of the circulation.

Among frogs, the most proper is the equuleus of Lieberkühn, described in the *Mém. de l'Acad. de Berlin*, 1745."

[b] " For the various opinions respecting the number and differences of the arterial coats, consult, among others, Vinc. Malacarne, *Della Osservat. in Chirurgia.* Turin. t. ii. p. 103.

And C. Mondini, *Opuscoli scientifici*, t. i. Bologna, 1817. 4to. p. 161."

creeping upon it[c]; it gives very great tone and elasticity to the arteries.

"II. The middle coat consists of transverse fibres[d], lunated or falciform, and *almost* of a fleshy nature: hence this has the name of muscular coat, and appears to be the chief seat of the vital powers of the arteries.

"III. The inner coat lining the cavity of the arteries is highly polished and smooth," and is called the serous coat. It is brittle, so as to be cracked by a blow, a ligature fixed around the whole artery, or torsion of the vessel, while the external coat remains entire. The middle coat may give way at the same time, but frequently lacerates, through the pressure of the blood, by degrees only; and the external coat will remain entire, merely dilated into a pouch, for a length of time, — a state called false aneurysm. Dr. Hales found the carotid of a dog burst at once by the pressure of a column of water less than 190 feet high.[e]

"This is much more distinct in the trunks and larger branches than in the smaller vessels.

"Every artery *originates*, either

"From the pulmonary artery (the vena arteriosa of the ancients), which proceeds from the anterior ventricle of the heart, and goes to the lungs;

"Or from the aorta, which proceeds from the posterior ventricle, and is distributed throughout the rest of the system.

"These trunks divide into branches, and these again into twigs, &c.

"According to the commonly received opinion, the united capacity of the *branches*, in any part of the sanguiferous system, is greater than that of the trunk from which they arise. But I fear that this is too general an assertion, and even that the measure of the diameter has been sometimes improperly confounded with that of the area. I myself have never been able to verify it, although my experiments have been frequently repeated, and made, not on vessels injected with wax, after the

[c] "Fr. Ruysch, *Respons. ad ep. problematicam.* iii. Also his *Thesaur. Anat.* iv. tab. 3."

[d] "B. S. Albinus, *Annot. Academ.* l. iv. tab. *5.* fig. 1."

[e] *Hæmastatics.*

bad example of some illustrious physiologists, but on the undisturbed vessels of recent subjects, *v. c.* on the innominata and its two branches—the right carotid and subclavian, on the brachial and its two branches—the radial and ulnar.[f]

"The inconstancy of the proportion between the capacity of the branches and that of the trunks is clearly shown by the various sizes of the vessels under different circumstances, *v. c.* by the relative capacity of the inferior thyreoid artery in the infant and the adult; of the epigastric artery in the virgin and the mother near her delivery; and also of the uterine vessels in the virgin and the pregnant woman; of the omental vessels during the repletion and vacuity of the stomach.[g]

"The arteries, after innumerable divisions and important anastomoses[h] connecting different neighbouring branches, *terminate* at length in the beginning of the veins. By this means the blood is conveyed back again to the heart. The distinction between artery and vein, at the point of union, is lost."

Some arteries terminate in cells; for instance, many of the penis and spleen.

"Another description of vessels arise universally from the arteries, and are called *colourless*, from not containing pure blood, either on account of their minuteness, or of their specific irritability, which causes them to reject that fluid."

"The blood conveyed from the heart throughout the body by the arteries is carried back by the *veins*.[i]

"These are very different in function and structure from the arteries, excepting, however, the minutest of both systems, which are indistinguishable.

"The veins, except the pulmonary, are universally more capacious than the arteries; more ramified; much more irregu-

[f] "See also J. Theod. Van Der Kemp, *De Vita*. Edin. 1782. 8vo. p. 51. And Seerp Brouwer, *Quæstiones Medic. varii argum.* Lugd. Batav. 1816. 4to. p. 8."

[g] "This is remarkably observable in the adult stag, by comparing the areæ of the external carotid and its branches, during the spring, just before the horns have attained their full growth, and when they are still covered with their downy integuments (called in German, *der Bast*), with such as they are after this covering has fallen off."

[h] "Ant. Scarpa, *Sull' Aneurisma*, Pav. 1804. fol. cap. 4."

[i] "H. Marx, *diatr. præmio ornata, de structura atque vita venarum*. Carlsr. 1819. 8vo."

lar in their course and division; in adult age, softer and far less elastic, but still very firm and remarkably expansile.

" Their *coats* are so much thinner that the blood appears through them. They are likewise less in number, being solely a cellular external, somewhat resembling the nervous of the arteries ; and a very polished internal, also nearly agreeing with that of the arteries.

" A muscular coat exists only in the trunks nearest the heart.

" The interior coat forms, in nearly all veins of more than a line in diameter, very beautiful valves of easy play, resembling bags, generally single, frequently double, and sometimes triple, placed with their fundus towards the origin of the vein, and their edge towards the heart.

" These valves are not found in some parts: not in the brain, heart, lungs, secundines, nor in the system of the vena portæ.

" The twigs, or, more properly, the radicles, of the veins, unite into branches, and these again into six principal trunks: viz. —

" Into the two cavæ, superior and inferior;

" And the four trunks of the pulmonary vein (the arteria venosa of the ancients).

" The vena portæ is peculiar in this, that, having entered the liver, it ramifies like an artery, and its extreme twigs pass into the radicles of the inferior cava, thus coalescing into a trunk.

" That the blood may be properly distributed and circulated through the arteries and veins, nature has provided the *heart* [k], in which the main trunks of all the blood-vessels unite, and which is the grand agent and mover of the whole human machine, — supporting this — the chief of the vital functions, with a constant and truly wonderful power, from the second or third week after conception to the last moment of existence."

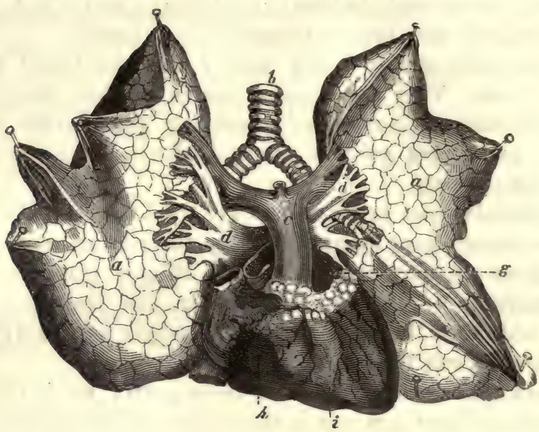
The heart is essentially a muscular organ, conical, with four cavities, placed in the left half of the chest, not quite vertically, but rather obliquely to the left, and from behind forward. Its size is usually about that of the closed fist of the individual.

" It is loosely contained in the *pericardium* [l], which is a membranous sac," consisting of two layers: the one fibrous and of the

[k] " W. Cowper, *Myotomia Reformata.* (Posth.) Lond. 1724. fol. max. Tab. xxxvi—xl."

[l] " Haller, *Elementa Physiol.* t. i. tab. i.

Nicholls, *Philos. Trans.* vol. lii. P. i. p. 272."



a, lungs.
b, trachea.
c, pulmonary artery.
d, pulmonary veins.
e, aorta.
f, right auricle.
g, left auricle.
h, right ventricle.
i, left ventricle.

same nature as the dura mater, though thinner; the other a true serous membrane, lining the inside of this, closely enveloping the substance of the heart, and " very firm, accommodated to the figure of the heart, and moistened internally by an exhalation."

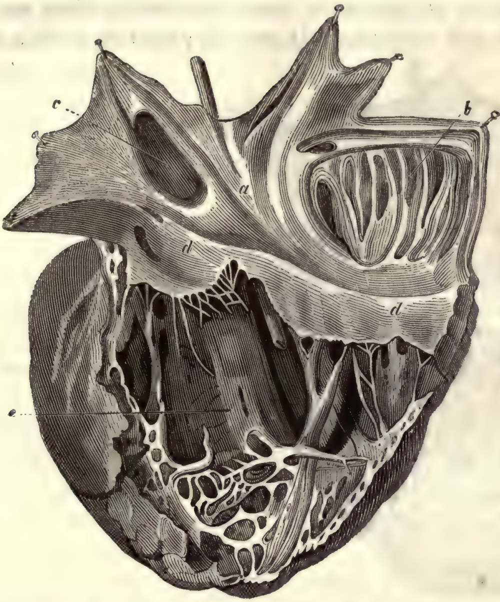
It lies between the two pleuræ, and behind the anterior, and before the posterior, mediastinum. " Its importance is evinced by its existence being, in red-blooded animals, as general as that of the heart; and by our having but two instances on record of its absence in the human subject. [m]

" The heart alternately receives and propels the blood. Receiving it from the whole body by means of the superior and inferior vena cava, and from its own substance through the common orifice of the coronary veins, that is supplied with a peculiar valve [n], it conveys that fluid into the anterior sinus and auricle, and thence into the corresponding ventricle, which, as well as the auricle, communicates with both orders of the heart's own vessels by the openings of Thebesius. [o]

[m] " Consult, *v. c.* Littre, *Hist de l'Académie des Sc. de Paris.* 1712. p. 37.
Baillie, *Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge*, t. i. p. 91."

[n] " Casp. Fr. Wolff on the origin of the large coronary vein, *Act. Acad. Scient. Petropol.* 1777. P. i.
Petr. Tabarrani on the same subject, *Atti di Siena*, vol. vi."

[o] " Respecting these openings, consult, among others, J. Abernethy, *Philos. Trans.* 1798. p. 103."

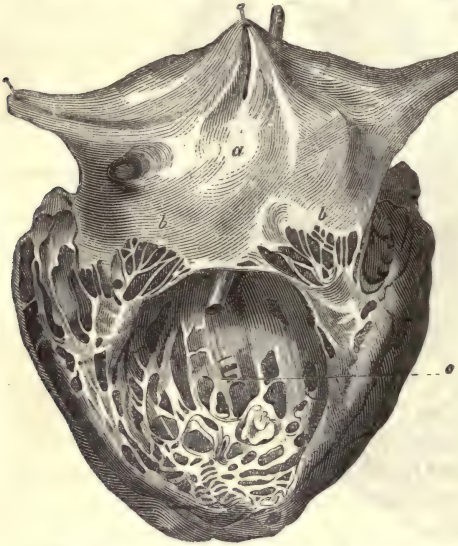


a, sinus of right auricle.
b, appendix of right auricle.
c, original seat of the foramen ovale.
d, tricuspid valve.
e, right ventricle.

"From this anterior, or, in reference to the heart of some animals, right, ventricle, the blood is impelled through the pulmonary artery into the lungs: returning from which, it enters the

a, right ventricle.
b, semilunar valves of pulmonary artery.
c, pulmonary artery: the aperture is the commencement of its right branch.

four pulmonary veins, and proceeds into their common sinus and the left, or, as it is now more properly termed, posterior, auricle. [p]



a, left auricle.
b, mitral valve.
c, left ventricle: a probe is passed through its opening into the aorta.

"The blood flows next into the corresponding ventricle; and

a, left ventricle.
b, semilunar valves of aorta.
c, aorta.

[p] "James Penada, *Memorie della Società Italiana*, t. xi. p. 555."

then, passing into the aorta, is distributed through the arterial system of the body in general and the coronary vessels of the heart itself.[q]

"Having proceeded from the extreme twigs of the general arterial system into the radicles of the veins, and from the coronary arteries into the coronary veins, it finally is poured into the two venæ cavæ, and then again pursues the same circular course.

"The regularity of this circular and the successive motion through the cavities of the heart is secured, and any retrograde motion prevented, by *valves*, which are placed at the principal openings, *viz.* at the openings of the auricles into the ventricles, and of the ventricles into the pulmonary artery and aorta."

"Thus the ring, or venous tendon, which forms the limit of the anterior auricle and ventricle, descending into the latter cavity, becomes these tendinous valves.[r] These were formerly said to have three apices, and were, therefore, called triglochine or *tricuspid:* they adhere to the fleshy pillars, or, in common language, the papillary muscles.

"In a similar manner, the limits of the posterior auricle and ventricle are defined by a ring of the same kind, forming two valves, which, from their form, have obtained the appellation of *mitral*."[s]

They are duplicatures of the lining membrane, with the addition of intervening fibrous membrane.

"At the opening of the pulmonary artery[t] and aorta[u] are found the triple *semilunar* or sigmoid valves[x], fleshy and elegant, but of less circumference than the mitral."

These are merely duplicatures of the lining membrane.

"It is obvious how these differently formed valves must prevent the retrocession of the blood into the cavities which it has left. They readily permit the blood to pass on, but are expanded,

[q] "Consult Achil. Mieg, *Specimen ii. Observationum Botanicarum*, &c. Basil, 1776. 4to. p. 12. sq."

[r] "Eustachius, tab. viii. fig. 6.—tab. xvi. fig. 3.—Santorini. Tab. Posth. ix. fig. 1."

[s] "Eustachius, tab. xvi. fig. 6."

[t] "Eustachius, tab. xvi. fig. 4."

[u] "Eustachius, tab. xvi. fig. 5.—Morgagni, *Adversar. Anat.* i. tab. iv. fig. 3. Santorini, l. c."

[x] "Consult Hunter, who treats very minutely of the mechanism of these valves in his work *On the Blood*, p. 159."

like a sail, against it, by any attempt at retrograde movement, and thus close the openings." The mere attempt at retrocession by the blood closes the semilunar valves: but the contraction of the muscular bands attached by tendons to the edges of the tricuspid and mitral valves during the systole of the ventricles will assist in closing the auriculo-ventricular openings.

"The *texture* of the heart is peculiar: fleshy, indeed, but very dense and compact, far different from common muscularity.[y]

"It is composed of fasciculi of fibres, more or less oblique, here and there singularly branching out, variously and curiously contorted and vorticose in their direction, lying upon each other in strata, closely interwoven between the cavities, and bound by four cartilaginous bands at the basis of the ventricles, which thus are, as it were, supported, and are distinguished from the fibres of the auricles."[z]

The heart was shown by Dr. Alexander Stewart[a], about the beginning of the last century, to be resolvable by boiling water into a semicircular muscle, with all its fibres running parallel to the base. Being rolled round in a funnel form, the left ventricle is produced with the apex, which thus belongs entirely to it; and the second turn produces the right ventricle, by the space between it and the first layer. The walls of the left ventricle, except the septum, are strengthened by another turn, which the right ventricle has not; so that the left ventricle is thicker than the right. The auricles are distinct, and by boiling drop off from the ventricles. They are very thin.

The interior of the heart is lined by the same membrane which forms the inner coat of the arteries and veins, being firmer and more opake in the left or arterial cavities, which are continuous with the arteries, than in the right or venous cavities, which are continuous with the venæ cavæ.

M. Gerdy has arranged the fibres of the ventricles into three orders — the one running from the heart's apex towards its base, and ending in tendons which are attached to the tricuspid

[y] "Leop. M.A. Caldani, *Memorie lette nell' Acad. di Padova*. 1814. 4to. p. 67."

[z] "Casp. Fr. Wolff, *Act. Acad. Scientiar. Petropol.* for the year 1780. sq., especially for 1781. P. i. p. 211. sq., on the cartilaginous structure of the heart, or on the cartilagineo-osseous bands, and their distribution at the base of the heart."

[a] *Phil. Trans.* vol. ix. abridg.

and mitral valves; the second detached in their centre, and fixed in the substance of the heart by their two extremities only; and the third fixed altogether in the substance of the organ.[b]

"The fleshy fibres are supplied with very delicate nerves[c], and an immense number of blood-vessels, which arise from the coronary arteries, and are so infinitely ramified[d], that Ruysch described the whole structure of the heart as composed of them."[e]

"By this structure the heart is adapted for its perpetual and equable motions, which are an alternate systole and diastole, or contraction and relaxation, of the auricles and ventricles in succession.

"The systole of the ventricles is performed in such a way that their external portions are drawn towards their septum, and the apex of the heart towards the base.[f] This at first sight seems disproved by the circumstance of the apex striking against the left nipple, and, consequently, appearing elongated, — a circumstance, however, to be attributed to the double impetus of the blood flowing into the auricles and expelled from the ventricles, by which double impetus the heart must be driven against that part of the ribs."

Dr. W. Hunter accounted for it thus in 1746: —

"The systole and diastole of the heart, simply, could not produce such an effect; nor could it have been produced, if it had thrown the blood into a straight tube, in the direction of the axis of the left ventricle, as is the case with fish, and some other classes of animals: but by throwing the blood into a curved tube, viz. the aorta, that artery, at its curve, endeavours to throw itself into a straight line, to increase its capacity; but the aorta being the fixed point against the back, and the heart in some degree loose and pendulous, the influence of its own action is thrown upon itself, and it is tilted forwards against the inside of the chest."[g]

[b] *Manuel d'Anatomie descriptive.* Par Jules Cloquet. Paris, 1825.

[c] "Scarpa, *Tabulæ Neurologicæ ad illust. Hist. Anat. cardiac. nervor.* tab. iii. iv. v. vi."

[d] "Ruysch, *Thesaur. Anat.* iv. tab. iii. fig. 1, 2."

[e] "Brandis has proposed an ingenious hypothesis to explain the use of so great an apparatus of coronary vessels. *Versuch über die Lebenskraft,* p. 84."

[f] "Consult Ant. Portal, *Mémoires sur la Nature & le Traitement de plusieurs Maladies,* t. ii. 1800. p. 281."

[g] *Treatise on the Blood,* &c., by John Hunter, p. 146. Note.

Dr. Barclay has the following passage on this point: —

Though this is generally allowed, Haller remarks that in the frog also, which has a straight aorta, the apex of the heart moves forwards during the contraction[h]; and, in opposition to Blumenbach's explanation, some say that while the heart of a dog, rabbit, &c., continues to palpitate, after being extracted from the chest, the apex is lifted up at each contraction of the empty ventricles.[i]

The occurrence is ascribable likewise, in some measure, to the distension of the auricles; for Haller found the apex give the usual stroke at the nipple, on his distending the left auricle with air[k], and Senac[l] has shown a similar influence from the right auricle also. When the ventricles are contracting, no blood can leave the auricles, which must, therefore, become distended by its accumulation.

It is equally evident, that, when the ventricles dilate again, the blood must rush into them from the auricles.

These considerations show, without experiment, that the auricles and ventricles are always in opposite states, — that, when the ventricles are in systole, the auricles are in diastole, and *vice versâ*.

On applying the ear or a stethoscope to the region of the heart, two successive sounds may be distinctly perceived. At the moment of the stroke of the heart against the ribs (which stroke may be felt more strongly if the person lies on the left side), and

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"When the blood is forced into the arteries, their curvatures, near where they issue from the ventricles, are from their distension lengthened and extended towards straight lines; and, causing the heart to participate in their motions, compel it to describe the segment of a circle, when the apex moving atlantad and sinistrad, is made to strike against the left side. The same kind of motion having also been observed by the celebrated Haller, in distending the left or systemic auricle, it must follow, that the stroke which is given to the side, may be the effect of two distinct causes, either acting separately, or in combination: but acting on a heart obliquely situated, as ours is, in the cavity of the thorax, where the aspect of the base is atlantad and dextrad, and that of the apex sinistrad and sacrad. In combination, as the first of the two, by removing the pressure, will facilitate the influx of the venous blood into the left or systemic auricle, which is situated dorsad; so the second, by the influx of blood into the auricle, will contribute in its turn to facilitate the circular motion of the heart, proceeding from the arteries." *The Muscular Motions of the Human Body*, p. 567.

[h] *El. Physiol.* t. i. p. 394.

[i] Professor Mayo, *Outlines of Human Physiology.* 1827. p. 68. Dr. Hope, &c.

[k] l. c. ibid. where he refers to Senac and Ferrein.

[l] *Traité du Cœur*, p. 357.

at the moment of the pulse of the arteries, at least of those nearest the heart, is heard a dull sound; and immediately afterwards, without any interval, a clearer sound, similar to the noise of a valve or to the licking of a dog. The first sound occupies about $\frac{2}{4}$ of the whole time; the second sound $\frac{1}{4}$ or $\frac{1}{3}$, and then a pause occurs of about another $\frac{1}{4}$. This is termed the *rhythm* of the heart's action.[m] The *sounds* of the heart are ordinarily heard in health between the cartilages of the fourth and seventh left ribs, and under the inferior part of the sternum; those of the left side of the heart in the former situation, and those of the right in the latter. The first sound is usually loudest at the lower part of the heart's region; the second, at the higher part, in the situation of the auricles.

Whatever may be the cause of these sounds, the first occurs at the moment the ventricles contract: for it occurs at the instant the aorta receives blood from the left ventricle; and we know that both ventricles contract simultaneously. We might presume that the second sound occurs at the moment the auricles contract, and that therefore the auricles part with their blood immediately after the action of the ventricles. Again, when we reflect that the moment the ventricles have contracted, they relax, as is proved by our feeling and seeing the walls of the chest instantly recover their position after being forced outwards by the stroke of the heart, and as their relaxation is the production of a cavity for the blood of the auricles, we may hence be certain that the auricles discharge their blood into the ventricles instantly after the ventricles have discharged theirs.

In truth, those who open living animals assert that they see the apex of the heart recede from the walls of the chest, and the ventricles expand, instantaneously after their contraction, and that, at this moment of expansion, the blood rushes into them from the auricles, and a retractile motion of the auricles occurs most observable at the sinus.[n] It requires no vivisection to show that this must be the case.

[m] See the lamented Dr. Laennec's immortal work, *Traité de l'Auscultation Médiate, et des Maladies des Poumons et du Cœur.* (Edit. 1. 1819.) Edit. 3.

The force and extent of the sounds and shock, and the rhythm of the heart's action, are variously altered in disease, and other sounds superadded, resembling that of a bellows, a file, a saw, a drum, a dove, &c., all highly interesting to a philosophic mind, and indispensable to be known to all practitioners but empirics.

[n] Dr. Hope's *Treatise on the Diseases of the Heart and Great Vessels.* London, 1832. p. 40.

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Dr. Whytt, and all old writers, declare, that, on opening living animals, they saw the auricles (that is, the appendix of the auricles) contract the first; and this is the modern experience of many. I have seen this in an ass stupified with prussic acid, opened by the desire of Dr. Hope. But in the same ass I repeatedly saw the appendices of the auricles contract many times to one contraction of the ventricles, resembling the tongue in the act of lapping, and repeatedly saw them contract after the ventricles. Whytt, though in experimenting upon a frog he saw the contraction of the auricle regularly precede that of the ventricle, says that the auricle continued to beat long after the ventricle had ceased: in an experiment upon a rabbit by Dr. Stevens, presently to be mentioned, it contracted for nearly three hours, though the ventricle was almost motionless. Sir B. Brodie, in all his experiments on dogs, rabbits, &c. never saw "any regular systole of the auricles corresponding to, and alternating with, that of the ventricles, and often used to observe several slight contractions of the auricle, especially of the appendix of the auricle, for one of the ventricle."[o]

The contraction of the appendices of the auricles is allowed to be very slight[p], and can hardly have much share in the circulation. The sinuses are always charged with blood, as reservoirs, and the appendices are probably intended only to enlarge the space by yielding under congestion. The contraction of the appendices is perhaps partly to prevent the blood from coagulating in them, as it might do, from their being blind pouches, were it not continually expelled. The sinuses of the auricles must part with some of their blood whenever the ventricles expand; and this period,—the moment after the contraction of the ventricles,—is the period at which the systole of the auricles must occur.

When the ventricles are nearly filled, and still more when contracting, the blood must accumulate in the auricles, and the stoppage be felt even in the large veins; for which reason, just before, or rather at, the moment of the systole of the ventricles, we sometimes see the jugulars swell.[q] Some have adduced the swelling of the jugulars before the stroke of the heart, as a proof that the auricles contract before the ventricles; but I have always found

[o] Dr. Hope's work, p. 37. sq. [p] Dr. Hope, l. c. p. 39.

[q] See my Lumleyan *Lectures on the recent Improvements in the Art of distinguishing the various Diseases of the Heart,* p. 16. folio, with copperplates. London, 1830.

it occur at the same moment with their stroke[r]; and the impossibility of passage into the ventricle explains the fact. Indeed, not only, according to my experience, does the swelling of the jugulars occur after the moment assigned by these writers to the contraction of the auricles, but, as, at the moment the auricles lose their blood, the ventricles are relaxed or expanding, there can be no reason for the blood moving at all backwards when the auricles contract.

The object of the appendix of each auricle usually contracting later than the sinus, that is, just before the ventricle, if it really does, is probably, by pouring its blood into the sinus which has just parted with much of its own to the ventricle, and by lessening the space for the blood streaming to the auricles from the veins, to bring the distension of the ventricle, which is already in diastole, to the highest pitch; or, if the expansion of the ventricle is spontaneous, to thus cause it to be supplied with blood in proportion to its expansion.

Many hypotheses have been invented to explain the two sounds; and the periods of the action of the auricles and ventricles relative to each other and to the arterial pulse been strangely misrepresented. But Laennec was right in asserting that the first sound occurs *when* the ventricles part with their blood, and the second *when* the auricles part with theirs; for the first occurs when the heart strikes against the ribs and the aorta receives a fresh quantity of blood from the heart, and the second, when the ventricles expand and the blood must rush from the auricles: the first is loudest in the ventricular region, the second in the auricular: and, when the appendices of the auricles were contracting with all sorts of irregularity, — with no relation to the contraction of the ventricles in the ass, I heard, by means of the stethoscope, the two usual sounds occur with the greatest regularity. We may therefore presume that the first arises from the rush of blood from the ventricles, and the second from the rush of blood from the sinuses of the auricles.

"The impulse imparted by the heart to the blood is communicated to the arteries, so that every systole of the heart is very clearly manifested in those arteries which can be explored by the fingers and exceed $\frac{1}{6}$ of an inch in the diameter of their

[r] I have at this time a patient whose external jugulars are enormously distended, and immediately above the clavicles, the most frequent spot, their pulsation may be seen and felt exactly synchronous with the radial pulse.

canal, and in those also whose pulsation can be otherwise discovered, as in the eye and ear. The effect upon the arteries has been called their diastole, and is perfectly correspondent and synchronous with the systole of the heart," in vessels not distant from it; but, in distant arteries, the pulse has long been observed sometimes a very little later than the systole of the heart.

If an artery of tolerable size is divided, the blood escapes in jerks; if of smaller dimensions, it flows continuously, but is projected further at the moment of the pulse; and if the artery is very small, it flows in an uniform stream.

"The quickness of the heart's pulsations during health varies indefinitely; chiefly from age, but also from other conditions which at all ages form the peculiar constitution of an individual, so that we can lay down no rule on this point. I may, however, be permitted to mention the varieties which I have generally found in our climate[s] at different ages, beginning with the new-born infant, in which, while placidly sleeping, it is about 140 in a minute.

Towards the end of the first year, about -	124
———————— second year - -	110
———————— third and fourth year -	96
When the first teeth begin to drop out -	86
At puberty about - - - -	80
At manhood about - - - -	75
About sixty - - - - -	60

"In those more advanced, I have scarcely twice found it alike." Like many others, I have counted it distinctly before birth, by applying the stethoscope to one side of the mother's abdomen. My observations have been made near the end of pregnancy, and I have counted 128 pulsations in a minute, while the mother's pulse was but about 80.

"The pulse is, cæteris paribus, more frequent in women than in men, and in short than in tall persons. A more constant fact, however, is its greater slowness in the inhabitants of cold climates.[t]

"Its greater frequency after meals and the discharge of semen, during continued watchfulness, exercise, or mental excitement, is universally known."

[s] "My observations differ but little from those made by W. Heberden in England, *Med. Trans.* vol. ii. p. 21. sq."

[t] "J. H. Schönheyder, *De Resolutione et Impotentia motus Muscularis.* Hafn. 1768. p. 15. With which work compare the observations of F. Gabr. Sulzer, *Naturgesch. des Hamsters.* p. 169."

It is commonly believed that the pulse of every person is quicker in the evening than in the morning, and some have supposed an increase of quickness also at noon. Upon these suppositions Dr. Cullen builds his explanation of the noon and evening paroxysms of hectic fever[u], as others had theirs of the evening exacerbations of all fevers[v], regarding them as merely aggravations of natural exacerbations. The existence of the noon paroxysms is doubtful, and the evening one cannot be so explained, if Dr. R. Knox is correct[w], though he is opposed to Haller, &c. His observations make the pulse to be slower in the evening, and quicker in the morning.

Dr. Heberden saw a woman fifty years of age, who had always an intermitting pulse, yet an able anatomist could discover nothing unusual after death; and two persons whose pulse was always irregular in strength and frequency when they were well, and became quite regular when they were ill.[x]

"The heart rather than the arteries is to be regarded as the source of these varieties, which we have, therefore, detailed here.

"Its action continues in this manner till death, and then all its parts do not at once cease to act; but the right portion, for a short period, survives the left. [y]

"For, since the collapsed state of the lungs after the last expiration impedes the course of the blood from the right side, and the veins must be turgid with the blood just driven into them from the arteries, it cannot but happen that this blood, driving against the right auricle, must excite it to resistance for some time after the death of the left portion of the heart.

"This congestion on the right side of the heart, during the agony of death, affords an explanation of the small quantity of blood found in the large branches of the aorta.

[u] *Practice of Physic.*

[v] Haller, *El. Physiol.* t. ii. p. 263.

[w] *Edinburgh Medical and Surgical Journal.* 1815.

[x] *Transactions of the College of Physicians.* London. vol. ii. p. 31. Similar cases are mentioned by Shenkius, De Haen, Monro, Rasori, and Andral.

[y] "Stenonis, *Act. Hafniens.* t. ii. p. 142.

Sometimes, though rarely, it happens that the right portion of the heart, oppressed with too much blood, becomes, contrarily to what usually takes place, paralysed before the left. This I have more than once observed on opening living mammalia, particularly rabbits."

"Weiss[z], and after him Sabatier[a], ascribe to this cause likewise the comparatively larger size[b] of the right auricle and ventricle after death, especially in the adult subject.

"The motion of the blood is performed by these two orders of vessels in conjunction with the heart. Its celerity in health cannot be determined; for this varies not only in different persons, but in different parts of the same person.

"Generally, the blood moves more slowly in the veins than in the arteries, and in the small vessels than in the large trunks, although these differences have been overrated by physiologists.

"The mean velocity of the blood flowing into the aorta is usually estimated at eight inches for each pulsation, or about fifty feet in a minute.

"Some have affirmed that the globules of the cruor move more in the axes of the vessels, and with greater rapidity, than the other constituents of the blood. I know not whether this rests upon any satisfactory experiment, or upon an improper application of the laws of hydraulics; improper, because it is absurd to refer the motion of the blood through living canals to the mere mechanical laws of water moving in an hydraulic machine. I have never been able to observe this peculiarity of the globules.

"My persuasion is still more certain that the globules pass on with the other constituents of the blood, and are not rotated around their own axis; — that besides the *progressive*, there is no *intestine* motion in the blood, although indeed there can be no doubt that the elements of this fluid are occasionally divided, — where they are variously impelled, according to the different direction, division, and anastomoses of the vessels.

"The moving *powers* of the sanguiferous system are now to be examined: first, those of the heart, by far the greatest of all; afterwards, those which are only subsidiary, though indeed highly useful.

"That the powers of the heart cannot be accurately calculated is clear, upon reflecting that neither the volume of blood projected at each pulsation, nor the celerity nor distance of its

[z] "J. N. Weiss, *De Dextro Cordis Ventriculo* POST MORTEM *ampliori*. Altorf. 1767. 4to."

[a] "Ant. Chaum. Sabatier, *E. in vivis Animalibus Ventriculorum Cordis eadem Capacitas*. Paris, 1772. 4to."

[b] "Sam. Aurivilius, *De Vasorum Pulmonal. & Cavitat. Cordis inequali Amplitudine*. Gotting. 1750. 4to."

projection, much less the obstacles to the powers of the heart, can be accurately determined, &c.

"A rough calculation may be made by taking every probable conjecture together: *v. c.*, if the mean mass of the blood is considered as 10 pounds, or 120 ounces; the pulsations 75 in a minute, or 4500 in an hour; and the quantity of blood expelled from the left ventricle at each contraction, as 2 ounces; it follows that all the blood must pass through the heart 75 times every hour.

"The impetus of the blood passing from the heart may be conceived by the violence and altitude of the stream projected from a large wounded artery situated near it. I have seen the blood driven at first to the distance of above five feet from the carotid of an adult and robust man.[c]

"This wonderful, and, while life remains, constant, strength of the heart, is universally allowed to depend upon its *irritability*, in which it very far surpasses, especially as to duration[d], every other muscular part.[e]

"That the parietes of the cavities are excited to contraction by the stimulus of the blood, is proved by the experiment of Haller, who lengthened, at pleasure, the motion of either side of the heart, by affording it the stimulus of the blood for a longer period than the other."[f]

[c] "The experiments of Hales, in which the blood was received into very long glass tubes fixed to the arteries of living animals, and the length of its projection measured, are indeed beautiful, like every thing done by this philosopher, who was calculated by nature for such enquiries. But, if the force of the heart is to be estimated in this way, we must take into account the pressure of the column of blood contained in the tube and gravitating upon the left ventricle.

"The result of Hales's calculations was, that, the blood being projected from the human carotid to the height of seven feet and a half, and the surface of the left ventricle being fifteen square inches, a column of blood, weighing 51·5 lbs. was incumbent upon the ventricle, and overcome by its systole. *Statical Essays*, vol. ii. p. 40. London, 1733. 8vo."

[d] "Thus, to say nothing of the phenomena so frequently observed in the cold-blooded amphibia and fishes, I lately found the heart of the chick to beat for twelve hours, in an egg, on the fourth day of incubation."

[e] "Consult Fontana, who treats of this prerogative of the heart minutely in his *Ricerche sopra la Fisica animale*, and limits it too much. Haller answered him in the Literary Index of Gottingen."

[f] "See Haller on the motion of the heart from stimulus. *Comment. Soc. Scient. Gottingens.* tom. i.

G. E. Remus, *Experimenta circa circulat. sanguin. instituta.* Gotting. 175 4to. p. 14."

The heart, however, of frogs, for instance, contracts and relaxes alternately, for a length of time, when out of the body and destitute of blood.

Sir B. Brodie divided the great vessels in rabbits, and found the action of the heart "apparently unaltered, for at least two minutes after that viscus and the great blood-vessels were empty of blood."[g] But the quantity of blood greatly influences the action of the heart.

"Since a supply of nerves and blood is requisite to the action of the voluntary muscles, it has been enquired whether these, both or either, are requisite to the heart also.[h]

"The great influence of the *nerves* over the heart, is demonstrated by the size of the cardiac nerves, and by the great sympathy between the heart and most functions, however different. A convincing proof of this is, the momentary sympathy of the heart during the most perfect health[i] with all the passions, and with the *primæ viæ* in various disorders.

"The great importance of the blood to the irritability of the heart is evident from the great abundance of vessels in its muscular substance.

"Besides these powers of the heart, there is another which is mechanical, dependent on structure, and contributing greatly, in all probability, to sustain the circulation. For, when the blood is expelled from the contracted cavities, a vacuum takes place, into which, according to the common laws of *derivation*, the blood from the venous trunks must rush, being prevented, by means of the valves, from regurgitating."[k]

[g] Dr. Cooke, *A Treatise on Nervous Diseases*, vol. i. p. 63.

[h] "On this dispute consult *v. c.* R. Forsten, *Quæstion. select. Physiol.* Lugd. Bat. 1774. 4to.

J. B. J. Behrends, *Dissert. qua demonstratur Cor Nervis carere,* Mogunt. 1792. 4to.

And on the other side, J. Munniks, *Observationes variæ.* Groning. 1805. 4to. Lucæ, *Obs. circa Nervos Arterias adeuntes.* Francof. 1810. p. 37. tab. ii."

[i] "And how much more so when the heart is diseased, is shown *v. c.* in Caleb Hillier Parry's *Inquiry into the Symptoms and Causes of the* Syncope Anginosa, *commonly called* Angina Pectoris. Bath, 1799. p. 114."

[k] "Andr. Wilson, *Inquiry into the moving Powers employed in the Circulation of the Blood.* Lond. 1784. 8vo. p. 35. sq.

And at great length in J. Carson's *Inquiry into the Causes of the Motion of the Blood.* Ibid. 1815. 8vo." Second edition, 1833.

The influence of a vacuum, pointed out by Rudiger[l], enlarged upon by Dr. Andrew Wilson, and mentioned as probable by Haller[m], John Hunter[n], &c., has been very ably displayed by Dr. Carson of Liverpool.

The quantity of the blood, the length of its course, and the various obstacles opposed to its progress, render, in his opinion, the mere propulsive power of the heart insufficient to maintain the circulation perpetually. But assistance must be given by the vacuum which takes place in all the cavities of the organ, when the contraction of the muscular fibres is over. The blood is thus drawn into each relaxed cavity, and the heart performs the double office of a forcing and a suction pump. The situation of the valves of the heart is thus explained. There are valves at the mouths of the two great arteries, because behind each of these openings is a cavity of the heart, alternately dilating and affording a vacuum, into which, were there no valves, the blood would be drawn retrograde. There are valves between the auricles and ventricles, because the contraction of the ventricles tends to impel the blood back into the auricles, as well as into the pulmonary artery and aorta. At the venous openings of the auricles no valves exist, because they do not open from a part ever experiencing a vacuum and the blood does not appear to leave the sinuses of the auricles so much by their contraction, which would impel it in all directions, like the ventricles, as by the vacuum offered it in the dilated ventricle; and therefore the blood of the auricles will not move retrograde, but will necessarily pass forwards into the ventricles, which are offering a vacuum. The inferior elasticity and irritability of the veins are also explained. If veins were capable

[l] Quoted by Haller, *El. Physiol.* t. ii. lib. vi. p. 325.

[m] His words are—"Sanguinem in auriculam dextram, tanquam in *vacuum* castellum approperare, ne id quidem videtur absque specie veri dici." l. c. An idea of the same kind appears to have been entertained before the time of Rudiger, whose work, *De Regressu Sanguinis per Venas mechanico,* was published at Leipsig in 1704. For in Pecquet's *Experimenta nova Anatomica,* published in 1651, arguments are adduced against those who conceived that the diastole sucked the blood towards the heart, ("num, ut quibusdam placuit, ATTRAHENDO pelliciat EXUGATVE, investigandum." Chap. vii. sqq.) At that time suction was not generally known to be merely a means of removing or diminishing the resistance to the pressure of air, but supposed to be an occult principle. He details experiments to show its true nature, but urges nothing against suction in the proper acceptation of the term, and his adversaries were right in their fact, though ignorant of its true nature.

[n] *A Treatise on the Blood,* &c. p. 185.

of contracting equally with arteries, on the diminution of their contents, the suction influence of the heart would constantly reduce their cavities to a smaller capacity than is compatible with their functions. The collapse of the veins by pressure, during the suction of the heart, is prevented by the fresh supply of blood afforded by the vis a tergo, which does exist, although it is not considered by him as of itself adequate to convey the blood back to the right auricle.

All allow that when the heart is relaxed its cavities enlarge, though some ascribe this to its elasticity, and others regard it as a necessary consequence of the arrangement of its fibres. Experiment proves the same. Dr. Carson extracted the hearts of some frogs, and immediately put them into water, blood-warm. They were thrown into violent action, and, upon some occasions, projected a small stream of a bloody colour through the transparent fluid. The water could not have been projected unless previously imbibed. It was thought that a stream of the same kind continued to be projected at every succeeding contraction; but that, after the first or second, it ceased to be observable, in consequence of the liquid supposed to be imbibed and projected losing its bloody tinge and becoming transparent, or of the same colour with the fluid in which the heart was immersed. The organ was felt to expand forcibly during relaxation, — a fact stated long ago by Pechlin[o], and subsequently by many others. Indeed, some consider the expansion of the heart as a change equally active with its contraction: conceiving, perhaps, that different fibres may act alternately, and produce expansion and contraction, just as the tongue may be retracted and protruded, and the iris lessened or enlarged.

Dr. Carson accounts, however, for the full dilatation of the heart upon another principle, upon the consideration of which it will be impossible to enter before the next section, where the subject will therefore be prosecuted.

" We must now enquire what powers are exerted by other organs in assisting the circulation. The existence of some *secondary* powers, and their ability to assist, or even in some cases to compensate for, the action of the heart, are proved by several arguments: *v. c.* the blood moves, according to many persons," in some parts to which the influence of the heart cannot reach,

[o] *De Corde.*

— in the vena portæ and placenta; not to mention instances of the absence of the heart.[p]

"The principal of these powers is the function of the *arteries*, not easy indeed to be clearly understood and demonstrated. 1. It is well known, that they have a peculiar coat, which is all but muscular. 2. That they are irritable, has been proved by repeated experiments.[q] 3. The size of the soft nerves arising from the sympathetic, and surrounding the larger arterial branches with remarkable networks, particularly in the lower part of the abdomen[r], argues the importance of these vessels in assisting the motion of the blood.[s]

"All know that the arteries pulsate, and indeed violently, so that if, *v. c.* we place one leg over the other knee, we find not only that it, but even a much greater weight, may be raised by the pulsation of the popliteal. Hence an alternate systole and diastole, corresponding with those of the heart, have long been assigned to them.

"But this, although commonly believed on the evidence of sense, is open to much question[t]: it may be asked, especially, whether this pulsation is referable to the power of the artery, or only to the impulse given by the heart to the blood propelled into the aorta.

[p] "See *v. c.* C. W. Curtius, *De monstro humano cum infante gemello*. Lugd. Bat. 1762. 4to. p. 39.

W. Cooper, *Phil. Transact.* vol. lxv. p. 316.

And, instar omnium, Fr. Tiedemann, *Anatomie der Kopflosen Missgeburten.* Landshut, 1813. fol. p. 70. sq."

[q] "Walter Vershuir, *De arteriar. et venar. vi irritabili: ejusque in vasis excessu; et inde oriunda sanguinis directione abnormi.* Groning. 1766. 4to.

Rich. Dennison, *Diss. arterias omnes et venarum partem irritabilitate præditas esse.* Edinb. 1775. 8vo.

Chr. Kramp, *De vi vitali arteriarum.* Argent. 1785. 8vo."

[r] "Observe, for instance, in Walter's *Tabulæ nervor. thorac. et abdominis,* the right hepatic, tab. ii. O. tab. iii. *l.*—the splenic, tab. ii. P., tab. iii. *m.*, tab. iv. *o.*—the superior mesenteric, tab. ii. Q., tab. iii. *f.*—the inferior mesenteric, tab. ii. T. —and many others.

Consult Soemmerring, *De c. h. fabrica.* t. iv. p. 362."

[s] "Haller, *De Nervor. in arterias imperio.* Gotting. 1744. 4to.

Lucæ, l. c."

[t] "T. Kirkland, *Inquiry into the present state of Medical Surgery.* London, 1783. 8vo. vol. i. p. 306. sq.

But especially Cal. Hillier Parry's *Experimental Inquiry into the Arterial Pulse.* Lond. 1816. 8vo."

"And indeed, after all, it appears that the *diastole* of an artery is owing to a lateral distension given by the impetus of the blood, so that the coats are expanded, and, by their elasticity, the next moment reacquire their natural thickness. To the same impulse may be ascribed the lateral motion of the axis, observable in the larger arteries, if serpentine and lying in loose cellular substance.

"The genuine *systole*, produced by a contraction of their substance, scarcely occurs, probably, while the heart acts with vigour, but may, when they are unusually influenced by local stimulants; whence the pulse during illness is very different in different arteries of the same person at the same time; or when the action of the heart itself fails," &c.

Most physiologists grant to the capillaries irritability, tonicity, or organic contractility; but some deny that *arteries* possess muscular properties. Bichat's objections are, the absence of contraction on the application of stimuli to them, the much greater resistance of the middle coat to a distending force than of muscular parts, and, lastly, the difference of the changes which it and muscles undergo both spontaneously and by the action of other substances.[u] Berzelius has multiplied the latter description of proofs.[x] However this may be, I must remark, first, that the capillaries have certainly vital powers of contraction as fully as any parts of the body. This appears in their various degrees of *local* dilatation and contraction, under inflammation, passions of the mind, &c. When different stimuli are applied to them, they are seen under the microscope locally to experience various degrees of contraction and dilatation, and this even after connection with the heart has been cut off by absolute excision of this organ.[y] Under similar circumstances, when no stimulus was applied, the blood was seen by Dr. Hastings often to cease, indeed, to flow, but still to oscillate. If the capillaries are allowed to possess organic contractility, it is impossible to say in which point of the arterial tract it begins.

The evidence of muscular fibres is not necessary to irritability. The iris and uterus are strongly endowed with irritability, but their muscularity is disputed by many. No muscularity is dis-

[u] *Anatomie Générale*, t. ii.   [x] *Traité de Chimie*, t. vii. p. 84. sq.

[y] See Dr. Wilson Philip, *On Febrile Diseases;* Dr. Thomson, *Lectures on Inflammation;* Dr. Hastings, *A Treatise on the Inflammation of the Mucous Membrane of the Lungs.* 1820.

cernible in the plant called dionæa muscipula, nor in the sensitive plant, nor in those zoophytes which appear gelatinous masses; yet contractility dependent on life is very manifest in them.

Verschuir actually found the larger arteries contract on irritating them with a scalpel, in fifteen out of twenty experiments.[z] Dr. L. Bikker, and J. J. Vandembos assert the same of the aorta, and Van Geuns of the carotid when influenced by electricity.[a] Zimmerman, Bichat, and Magendie, saw the arteries contract upon the application of acids, but the two last considered it a chemical change. Dr. Hastings, however, saw the same from the application of ammonia. When a ligature was placed on the aorta of a frog by Dr. M. Hall, the circulation was almost instantly arrested, first in the capillaries, then in the veins, and the blood, during ten or fifteen minutes, would move on in the arteries for some seconds, and then all at once rapidly retrograde, and so alternately.[b] J. Hunter found the posterior tibial artery of a dog contract so as nearly to prevent any blood from passing through it on merely being laid bare, and facts similar to this are mentioned by Drs. Hastings, Fowler[c], Jones[d], and the Drs. Parry. Dr. Stevens destroyed a rabbit's brain with a bodkin, and opened the chest. The lungs collapsed, and the heart lay motionless. On opening the pericardium, a branch of the coronary arteries on the right ventricle began to contract, and acted forcibly till it had driven all its blood into the ventricle. It now was still, and the right auricle began to contract, and continued acting for two hours and three quarters, the ventricle being almost motionless.[e] Dr. Marshall Hall says, that the superficial muscles and heart of batrachian reptiles become rigidly contracted by water of 120°; and that, if an artery and vein be also plunged in it, the artery grows rigid like muscles, and cylindrical, while the vein suffers no apparent change.[f] The fact of continued contraction, and of alternate contraction and relaxation in arteries, being occasioned by stimuli, is therefore certain; and, although some have not succeeded in stimulating them, we must remember that others have

[z] *De Art. et Ven. vi Irrit.*

[a] See Hastings, l. c. The introduction to this work is a body of information on the present subject.

[b] *A Critical and Experimental Essay on the Circulation*, &c. by Marshall Hall, M.D. London, 1831. p. 78.

[c] *Disputatio inauguralis de Inflammatione.*

[d] *On Hæmorrhage.*

[e] l. c. p. 57.

[f] l. c. p. 78.

failed in the application of electricity to parts indisputably muscular; — Verschuir [g] in the case of the heart and urinary bladder, and Zimmerman in other parts of known muscularity. [h] Dr. Hastings caused contraction in veins also by the application of stimuli. [i]

Dr. Parry instituted a number of experiments upon this question. After exactly ascertaining the circumference of arteries in animals, he killed them, and again measured the circumference; and after a lapse of many hours, when life must have been perfectly extinguished, he measured the circumference a third time. Immediately after death, the circumference was found greatly diminished, and on the third examination it had increased again. The first contraction arose from the absence of the blood, which distended the vessels and antagonised its efforts to contract; and it was evidently muscular, or, to speak more correctly, organic, contraction, because, when vitality had ceased, and this kind of contraction could no longer exist, the vessel was, on the third examination, always found enlarged. [k]

The forced state of distension in arteries was proved by the contraction immediately occurring on making a puncture in a portion of vessel included between two ligatures. An experiment of Magendie's is of equal weight, in which a ligature was fixed on the whole of a dog's leg except the crural artery and vein, and the vein and artery were compressed, when, upon wounding the vein, the artery completely emptied itself. [l] The capacities of arteries are thus always accommodated to the quantity of blood, and this circumstance gives the arterial canal such properties of a rigid tube as enable an impulse at the mouth of the aorta to be instantly communicated throughout the canal. This appears the great office of the contractile powers of arteries, for,

[g] l. c. expt. 22. [h] *De irritabilitate.* [i] l. c. p. 52. sq.

Dr. M. Hall thought he found an artery, which branches off from the vessels that by their union form the aorta in the frog and toad, pulsate a considerable time after the removal of the heart, becoming straight and pale; whereas the pulmonary artery grows more tortuous and distended at the moment of the stroke of the heart. This, however, is no more a proof that arteries in other animals have muscular powers, than it is that other arteries in the same animal have muscular powers and exhibit the same phenomenon: and Dr. Müller (*Ph. Tr.* 1833) maintains that the vessel is a vein which beats only from the impulse of lymph sent into it through a lymphatic by a lymph-heart.

[k] See also J. Hunter, *On the Blood*, pp. 114. 116.

[l] *Journal de Physiologie*, t. i. p. 111.

They do not incessantly dilate and contract to any amount, as many imagine. They lengthen and become tortuous, so that John Hunter says, "instead of the term diastole it should rather be called the elongated state."[m] Dr. Parry, on the most careful examination, could never discover the least dilatation in them during the systole of the ventricle — when the pulse is felt. Dr. Hastings declares he has seen it, as does Magendie in the case of the aorta and carotid of the horse; but from the number and accuracy of Dr. Parry's experiments, I incline to believe it does not occur in the ordinary undisturbed state of the circulation to any extent. Sir David Barry plunged his arm into the thorax of a horse, and found the aorta constantly full, nearly to bursting, not perceptibly varying in distension for an instant, though he held it during five minutes and examined it afterwards again; while at every expiration the cava was so empty as to feel only like a flaccid thin membrane.[n] The fact of a continued stream occurring from a *wounded* artery, only augmented at each pulsation of the heart, is thought by Magendie[o] to prove that the arteries assist in propelling the blood: but an opening takes off the resistance to its course so considerably that the vessel cannot but contract between the impulses of the heart.

Although the blood is constantly streaming onwards, the pulse is felt only when arteries are more or less compressed; under which circumstance, the motion of the blood onwards, by the impulse of a fresh portion from the left ventricle, is impeded: and this effort of the fluid against the obstructing cause gives the sensation called the pulse[p], which follows the stroke of the heart successively later throughout the arterial system, though the interval is in general too minute to be appreciated. Sir D. Barry found no pulsation in the aorta of the horse unless he compressed it violently.

[m] *On the Blood*, p. 175.

[n] *Dissertation sur le Passage du Sang à travers le Cœur*. Paris, 1827. p. 78. Also, *Annales des Sciences Naturelles*, Juin, 1827.

[o] *Journal de Physiologie*, t. i. p. 110.

[p] *An Experimental Enquiry into the Nature, Causes, and Varieties of the Arterial Pulse*, &c., by Caleb Hillier Parry, M.D. F.R.S. 1816. Likewise a second work, entitled, *Additional Experiments on the Arteries of warm-blooded Animals*, &c., by Chas. Hen. Parry, M.D. F.R.S. 1819.—the latter displays as much talent and learning as the former of originality. Dr. Young, in a Croonian lecture, highly worth perusal, on the functions of the heart and blood-vessels, reasons to prove that the muscular power of arteries has very little effect in propelling the blood. *Phil. Trans.* 1809.

The elastic coat both assists and antagonises the muscular: assists it in preventing distension when the distending force is very strong, and antagonises it — tends to prevent the canal from becoming too narrow — when it attempts to contract the vessel excessively.[q]

Still, independently of the whole quantity of blood, and of the heart's action, particular arteries may be in various degrees of distension, according to the various states of their individual contraction. For example, when a finger has a whitlow, the digital branches are found larger than usual at the very roots of the fingers; in many affections the pulse of the two wrists differ for a time. In fact, their condition may vary like that of the capillaries, and probably does vary every time that altered circulation occurs in a part, although Dr. Parry's opinion holds true during the tranquil and ordinary condition of circulation. I am thus inclined to agree with and differ from both Dr. Parry and Dr. Hastings; believing the former to be right as to the ordinary state, the latter in irregularity. In some diseases the action of the heart is strong and the pulse weak, and *vice versa;* so that it is frequently right to examine both.

The elastic power is said to be greater in the arteries, and the muscular in the capillaries; and as the muscular power is proved by Dr. Parry's experiments to be able to overcome the elastic in the arteries, it must be very considerable in the capillaries.

Dr. Curry, a late lecturer on the practice of medicine at Guy's Hospital, concluded, without doubt hypothetically, from some microscopic experiments which he had made on inflammation in the presence, once of Sir Charles Bell and once of Mr. Travers, that the circulation is indispensably facilitated by a sort of electric repulsion between the vessels and their contents, and that in inflammatory accumulation, the tone of the vessels being impaired, this repulsion is diminished, and the blood passes onwards with difficulty in consequence.[r]

" Since Whytt[s], especially, and other illustrious physiologists

[q] On the operation of the elastic and muscular coats, see J. Hunter, l. c. p. 118. sqq.

[r] See the *Syllabus* of his lectures for 1810.

[s] " Consult his *Physiological Essays, containing an inquiry into the causes which promote the circulation of the fluids in the very small vessels of animals.* Second edition, Edinb. 1761. 12mo.

H. v. d. Bosch, *über das Muskelvermögen der Haargefässgen.* Munster, 1786. 8vo."

have been convinced that the influence of the heart could not reach the extreme arteries and the origins of the veins, they have ascribed the progression of the blood in those vessels to a kind of *oscillation*."

These oscillations are quite imaginary, and now disallowed. Although variations of dilatation must affect the course of the blood through vessels, it is difficult to conceive how any regular action of them can assist it, while the blood is propelled by and drawn to the heart; and the influence of the heart was seen by Dr. Hastings, in some microscopical experiments in which partial obstruction was produced, to extend to arteries, capillaries, and veins, as the blood in them all received a sensible impulse at each contraction of the ventricles. Indeed, we have ocular proof that the capillaries do not contract on the blood in the ordinary state of things; for the blood in them, as well as in the arteries and veins, may be seen for an hour together in the frog's foot, under the microscope, to move in a stream unvarying — neither becoming finer alternately nor experiencing impulses.[t]

In fœtuses without hearts[u], it is not proved that the vascular system carries on the circulation by its own power, because a twin without a heart has never been seen, unless accompanied by a perfect fœtus, whose heart might circulate the blood of both; for placentæ often communicate, so that one child has died of hæmorrhage from the chord of the other: and in the only case where the matter was ascertained[x], the akerious fœtus was actually injected by the navel-string of the perfect fœtus.[y] When, however, the blood is not moved by the heart, the capillaries do impel it. Dr. Wilson Philip once saw it moving freely in some mesenteric capillaries of a rabbit for an hour and a quarter after the excision of the heart[z]; and Haller and Bichat made similar observations.

Mr. Burns[a], anxious to prove that the arteries are of more importance than the heart, that they themselves circulate the

[t] Dr. Hastings, l. c. p. 46. sq. Dr. Magendie, *Journal de Physiol.* t. i. p. 107. sq. says that the blood streams in the arteries and veins of cold-blooded animals, as if the vessels were motionless.

[u] Hewson, *Exp. Enquiry*, v. ii. p. 15. Sir B. Brodie, *Phil. Trans.* 1806.

[x] *Phil. Trans.* 1793. p. 155.

[y] Dr. Young, *Introduction to Med. Literature.* 1823. 2d edit. p. 631. sq.

[z] *An Experimental Enquiry into the Laws of the Vital Functions.* 3d ed. expt. 67.

[a] *Observations on some of the most frequent and important Diseases of the Heart,* &c. By Allan Burns. 1809. p. 117. sqq.

blood which they receive[b], and that the auricles are of more importance than the ventricles, mentions, among other examples of diseased heart, one in which both ventricles were as completely ossified as the cranium, except about a cubic inch at the apex, and in which there had been no palpitation or pain in the heart. As bony ventricles could not contract, nor easily be moved, palpitation could not readily have occurred, and pain rarely attends the ossification of any part. That the circulation was deranged is proved by the woman having experienced great dyspnœa, expectoration, and dropsy. The auricles were healthy, and thicker than usual, and had evidently performed the duty of the ventricles, through which, as an unchanging reservoir between the auricles and the pulmonary artery and aorta, the auricles drove the blood. The invariable languor of circulation in cases where the action of the heart is languid, proves the power of the heart in the circulation.

On the other hand, the large arteries of the extremities are continually found ossified, though not obstructed, without any apparent deficiency of circulation. I have seen long tracts of vessels in the lower extremities ossified, where no such circumstance had been suspected. Mr. Burns himself mentions an instance "of the arteries of the head, pelvis, legs, and arms, being almost entirely ossified[c]," the heart and aorta being healthy; and yet the man clearly died of diseased liver induced by hard drinking, hot climate, &c.

The ventricles are certainly of more importance than the auricles, because these are absent in many animals, and are only reservoirs to supply the ventricles, when the extremities of the great veins at the heart are not of very ample dimensions.[d]

"It remains for us now to examine the aid given to the returning blood by the *veins*, their radicles not being taken into the account. We should conclude at first sight that they have far less active power[e] than the rest of the sanguiferous system, and

[b] l. c. p. 120. [c] l. c. p. 124. sq. [d] J. Hunter, l. c. p. 138.

[e] "What is commonly, but improperly, called the *venous pulse*, observable on opening living animals, and in some morbid affections, and also under a violent effort, does not correspond with the action of the heart, but with respiration; since, if an expiration is unusually deep and lengthened, and the reflux of the blood to the lungs thus impeded, the jugular vein swells as far as the brain, the subclavian as far as the basilic, and the inferior cava as far as the crural." But there is also in some diseases of the heart a pulse of the lower portion of the external jugulars, synchronous with the systole of the ventricles, and dependent, as already explained, on the interrupted progress of the blood to the ventricles during their contraction. A vein may pulsate from its proximity to an artery.

that the return of their purple blood to the heart is chiefly ascribable to the impetus a tergo of the arterial blood, and to their valvular structure, which prevents any reflux. The efficacy of the valves in this point of view, is shown by the distensions and infarctions of the veins in the lower part of the abdomen, which are found destitute of valves.[f]

"The existence of vital powers in the venous trunks is probable[g], from the example of the liver and placenta, and from experiments instituted on living animals. We formerly mentioned the muscular layer in the extreme veins near the heart."

In a young lady, whom I attended, before the days of auscultation, for chronic bronchitis accompanied by violent cough, and who ultimately recovered, *all* the veins of the back of the hands and fore-arms distinctly pulsated synchronously with the arteries. Hunauld and Laennec each saw a similar case.[h] An universal pulsation of the veins synchronous with that of the arteries, occurred for some days twice in a young man who died of cerebral disease, with constriction of the mouth of the aorta[i]; once in a middle-aged man with affections of the head and abdomen, who recovered[j]; once in a middle-aged man who died with dropsy and palpitation[k], and in a girl who died with symptoms of hydrocephalus.[l] In a case of epidemic fever, the same was observed by Weitbrecht for twenty-four hours[m]; and he had previously seen a similar case, but doubted his senses. Haller's remark upon it is, "Ego quidem non intelligo."[n]

In venesection at the bend of the arm, I have frequently seen the jet regularly stronger at each pulsation of the heart; and J. Hunter mentions the same thing, and states it to be more observable at the head or foot, saying, "The fact is, however, that there is a pulsation in the veins.[o]

Yet ordinarily there is, speaking of the veins in general, no venous pulsation, and the stream in the veins, though caused

[f] "G. E. Stahl, *De vena portæ porta malorum*. Halæ, 1698. 4to."

[g] "Lister, *De humoribus*, p. 25."

[h] Laennec, l. c. p. iii. s. ii. ch. ii.

[i] *Journal Complimentaire*, t. 21. June, 1825.

[j] *Journal der Praktischen Heilkund*. Sept. 1815.

[k] *Archiv. für Medinische Erfahrung*. July and August, 1822.

[l] *Dublin Hospital Reports*, vol. iv.

[m] 1736. Haller's *Disputationes*, t. v. p. 407.

[n] *El. Phys.* t. ii. p. 356.

[o] l. c. p. 186. sq.

mainly by the left ventricle,—as may be seen by tying all the vessels of an extremity but the artery, and wounding the vein, when the jet from the vein may be regulated by pressing the artery,—is perfectly uniform. By the infinite subdivisions and great increase of capacity of the arterial system, the blood, which is moved in jerks in the larger arteries, giving a pulse, and, if the vessel is wounded, flowing more forcibly at the heart's pulsation, gives no pulse in the small vessels, and, if they are wounded, flows regularly; and in the capillaries, through the augmentation of space, experiences no increased momentum at the heart's pulsation. When the capillaries unite into veins, and the capacity of the whole vascular channel diminishes, the blood moves more quickly again through the diminished space[p]; but, though the smaller space augments its flow again, the impulses of the heart lost in the capillaries cannot be felt in the veins, and the current in them is smooth. Neither, generally speaking, is it by any means so rapid as in the arteries, because much of the heart's force is expended, and the veins are generally so much more numerous than the arteries, and the space, therefore, however less than in the capillaries, still much greater than in the arteries. Nor ought the momentum to be strong when the veins have all united into the cavæ, because it has only to reach the heart, where there is no resistance, but, on the contrary, more than one source of vacuum prepared; whereas in the aorta it ought to possess a force sufficient to carry it a great distance, and surmount great obstacles.

When the veins have pulsated, the action of the heart must have been very violent, or some obstruction occurred, which, in Dr. Hastings's experiments, was seen to cause the heart's action to be sensible in the capillaries and veins.[q]

There is always a pulsation in the large veins near the heart: but that arises from obstruction, as I have already mentioned.

"These are the chief powers which move the blood, and depend upon the structure and vitality of the sanguiferous system. We say nothing of the effect of gravity, attraction, and other properties, common to all matter. The more remote assistance derived after birth from particular functions, *v. c.* respiration and muscular motion, will appear in our account of those functions."

[p] Dr. Hastings, when observing the circulation in the frog's foot under the microscope, saw that the blood moved "faster in the arteries than in the veins, and in the veins than in the capillaries." l. c. p. 47.

[q] l. c. p. 47. sqq.

The heart of *mammalia* and *birds* has no peculiarity necessary to be mentioned here. In most *amphibious animals*, the arteries of the system as well as of the lungs spring from the right ventricle, with which the left, that sends off no vessel, communicates: hence their circulation continues under water. In *amphibious mammalia* and diving birds, some vessels, especially one vena cava, are dilated, to form a receptacle during the suspension of respiration. The heart of *fish* is extremely small, and has but one auricle and ventricle, the latter propelling the blood to the gills, from which it streams to the system through a large artery. Neither blood-vessels nor absorbents have been discovered in *insects*, yet a large tube pulsates in their back; and Professor Carus has lately discovered a circulation in them through a granular substance, the streams running to the posterior end of this vessel, and issuing again from its anterior end. With respect to the *mollusca*, the cuttle-fish has three detached hearts, consisting of a ventricle only, two for the gills and one for the aorta; the rest have a simple heart, the blood of the cava passing through the gills before it reaches the heart. The same is the case with the *crustacea*, and their heart has no auricle. *Worms* have circulating vessels distinctly contracting and dilating, but no heart, and their veins communicate with the general cavity of the body, and probably absorb. *Zoophytes* have no heart, nor circulating system, properly so called. In the echinus, indeed, there are two vessels that run along the intestines, and are thought to be an aorta and vena cava. But currents may occur, and not be perceptible if the fluid is colourless, or has no globules; and currents have been lately discovered by Mr. Lister in some zoophytes exactly similar to the currents long observed under the microscope in the tubes of stone-wort; the streams running first in one direction, on the internal surface of a tube, and then returning in another on the same surface. Such streams on surfaces or through cells are very wonderful.

According to Dr. M. Hall, when the office of a part in brutes is simple, the distribution of blood-vessels is simple, as in the fin or tail of a fish, and the arteries chiefly become veins: but when its office is complicated, as in the toes of the frog, or the blood has to be thoroughly exposed to air, as in the lungs, the arteries give off a number of branches, which do not diminish in diameter or give off others, and are peculiarly called by Dr. Hall capillaries, as large as, or larger than, their parent branch, freely anastomosing, not diminishing in size, nor giving origin to or running into the sides of veins. In the lungs, the large vessels presently split into capillaries; in the systemic arteries, the vessels diminish and subdivide considerably beforehand.

Vegetables have no central organ of circulation. The sap rises ordinarily through the cells, or, according to Decandolle, the intercellular spaces of the wood. Some plants are altogether cellular. The vessels in the wood of those which are vascular are found to contain air only, and the sap sometimes takes so circuitous a route, is so diffused, and so subsides to the lowest parts, that it cannot, in all cases at least, be confined to vessels. The sap rises chiefly in the newest layer of wood, called alburnum. But when the buds are preparing for developement, and the leaves are not yet complete, the sap is termed nursling sap, and ascends through the oldest and innermost layer of wood, and passes through unknown channels to the buds, combining probably with nutriment formerly

deposited. This nursling sap has been compared to the milk elaborated for the young of animals. The returning or descending sap passes through either vessels or intercellular spaces, chiefly along the innermost layer of bark, and some along the outermost layer of wood, where it must mix more or less with the ascending sap. In cellular plants, of course, the passage cannot be through vessels, and perhaps it passes through cellular tissue in all. The motion of the sap both in cellular tissues and vessels is explained, according to M. Raspail, by the fact of the inner surfaces of the cells and vessels of vegetables, &c. absorbing and exhaling rapidly, by which motion is given to the fluid and a current is established. (l. c. p. 317. sqq.) The power propelling the sap is such, that, if a piece of the stem is cut out, it entirely empties itself; and the sap has been found to flow from the extremity of a branch with a force sufficient to overcome a column of water 43 feet $3\frac{1}{3}$ inches in height. (Hales, *Statical Essays*, vol. i. p. 101.)

It would not be right to terminate this section without a note upon the discovery of the circulation of the blood;—a truth of which the ancients are thought to have remained ignorant, from finding the arteries empty after death. But they knew that these contained blood during life, as Galen (*De Anat. Admin.* vii. 15.) relates some amusing anecdotes of his pupils and some persons who promised to prove the arteries empty. The discovery was made by our countryman, Dr. Harvey, Physician to St. Bartholomew's Hospital, and promulgated by him at the age of forty-one, in an anatomical and surgical course of lectures at the College of Physicians, in 1619. He is entitled to the glory of having made it, says Hume (*History of England*, ch. 62.), "by reasoning alone, without any mixture of accident." He informed Boyle, that he was led to it by reflecting on the arrangement of the valves of the heart and veins, as exhibited by his master Fabricius. Nothing, he knew, was planned in vain, and they clearly allowed a fluid to pass but one way. By this argument, and the fact of a ligature upon an *artery* causing the blood to accumulate in it on the side *nearest* the heart, and, upon a *vein, beyond* the ligature; and that animals bleed to death by wounds in arteries or veins, he chiefly established his doctrine. After his time it was demonstrated with the microscope in cold-blooded animals. His immediate reward was general ridicule and abuse, and a *great* diminution of his practice [r]; and no physician in Europe, who at the time had reached forty years of age, ever, to the end of life, adopted his doctrine of the circulation of the blood. (Hume, l. c.) When the truth could be denied no longer, he was pronounced a plagiarist; the circulation was declared to have been known to Plato; nay, more, to king Solomon. (See Haller, *El. Physiol.* t. i. p. 243.) The circulation through the lungs had certainly been taught about

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[r] This he laments in a letter to a friend, as may be seen in a MS. of the Royal Society, referred to in the Life prefixed to the College edition of his works: — "Quod multo rarius solito ad ægros invisendos accersitus esset, postquam librum de motu cordis ediderit."

seventy years previously by Servetus[s], a Spanish physician of great anatomical knowledge, and original and active mind[t], who was *slowly* burnt to death, Oct. 27. 1553, the fire being made to last two hours by means of wood small in quantity and green, through Calvin, for not happening to be in all his writings of the same opinion as himself upon a point in divinity. Calvin was honourable enough to produce private letters in evidence of the difference of the opinions of Servetus from his own, and fancied himself to be a Christian.

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[s] His words are,—" sanguine, quem dexter ventriculus cordis sinistro communicat. Fit autem communicatio hæc, non per parietem cordis medium, ut vulgo creditur, sed magno artificio, a dextro cordis ventriculo, longo per pulmones ductu, agitatur sanguis subtilis; et a vena arteriosa, in arteriam venosam transfunditur. Deinde, in ipsa arteria venosa inspirato aeri miscetur, *expiratione a fuligine repurgatur.* Atque ita tandem a *sinistro cordis ventriculo totum mixtum per diastolem attrahitur,* apta suppellex, ut fiat spiritus vitalis. Quod ita per pulmones fiat communicatio et præparatio, docet conjunctio vario, et communicatio venæ arteriosæ cum arteria venosa in pulmonibus. Confirmat hæc magnitudo insignis venæ arteriosæ, quæ nec talis, nec tanta facta esset, nec tantam a corde ipso vim purissimi sanguinis in pulmones emitteret ob solum eorum nutrimentum, &c. Item, a pulmonibus ad cor non simplex aer, sed mixtus sanguine mittitur per arteriam venosam: ergo, in pulmonibus, fit mixtio, &c. Illa itaque spiritus vitalis, a sinistro cordis ventriculo, in arterias totius corporis deinde transfunditur, &c. Sicut, in transfusione a venis in arterias, est in pulmone novum genus vasorum, ex vena et arteria, &c." If we could be satisfied that by *spiritus vitalis* Servetus meant blood, we should say that he had also described the general circulation, because he mentions the course of the vital spirit from the left ventricle into the arteries throughout the body, and the course of the blood from the right side of the heart implies the course of it from the body or some part to the right side of the heart. The expressions *per diastolem attrahitur* might almost persuade us that he was acquainted with the influence of the vacuum from the expansion of the ventricles: and his account of the office of respiration to liberate the blood from its soot, *expiratione a fuligine repurgatur,* completely agrees with the discovery of the separation of carbon; while the doctrine that *a pulmonibus ad cor, aer, mixtus sanguine, mittitur per arteriam venosam,* accords with the present doctrine of the absorption of a portion of the air.

I am indebted for this most interesting quotation to the *Medical Dissertations* of Dr. Sigmond (ed. 2. 1828), who possesses a copy of Servetus bequeathed to him by Dr. Sims, for many years President of the London Medical Society, and supposed by Dr. Sims to be the only copy not burnt by the furious Calvin; to have been secreted and saved by Dr. Colladon, one of the judges; to have passed to the Landgrave of Hesse-Cassel, and then to Dr. Mead, who had nearly completed a quarto edition of it, when, at the instance of Gibson, Bishop of London, the edition was seized, May 27. 1723, and burnt, with the exception of a very few copies. The Duc de Vallière gave nearly 400 guineas for the book, and at his sale it brought 3810 livres. Dr. Sigmond, however, does not believe it to be the original copy.

[t] In the words of an Harveyan oration by Sir George Baker, " Vis illa animi tam vivida, tam libera et erecta, impatiens magistri."

CHAP. XII.

RESPIRATION, AND ITS PRINCIPAL USE.

"THE *lungs*[a], closely connected with the heart both by proximity and by relation of function, are two viscera," of the shape and size of the thorax, which they fill; with a very large base, like a horse's hoof; the right divided into three lobes, the left into two; "so light as to swim in water, and composed of a spongy, but pretty tenacious and elastic[b], parenchyma."[c]

Like other cavities, the chest is lined by a serous membrane, by which is meant a close sac, translucent[d] during life and health, and coherent by cellular membrane externally with every thing in contact,—with parietes and viscera; internally smooth, unattached, in contact only with the opposite portions of itself, and moistened by serum.[e] A serous membrane thus affords an external coat to viscera, insulates them, and facilitates their movements.

Each lung has a serous membrane, called Pleura, so that the pleuræ are two closed sacs, one of which lies over each lung,

[a] "Soemmerring and Reisseisen, *über die Structur, die Verrichtung und den Gebrauch der Lungen. Zwey Preischriften.* Berlin, 1808. 8vo."

[b] "J. Carson, *On the Elasticity of the Lungs,* in the *Phil. Trans.* 1820. p. 29. Consult also, Const. Ern. de Welzien, *De Pulmonum autenergia, &c.* Dorpat, 1819. 8vo."

[c] "Respecting all the organs concerned in respiration, consult Corn. J. Van Den Bosch, *Anatomia Systematis Respirationi inservientis Pathologica.* Harlem, 1801. 4to. pp. 1—44."

[d] M. Richerand tells us, that, on removing a portion of the thorax when cutting away a cancer, he saw the heart through the pericardium. *Journal de Médecine,* 1818.

[e] Dr. Marshal, from many experiments, believed that this is not the case, but that, whenever fluid is discovered, we must regard it as the effect of either disease or the struggle of dying. His experiments were made on the ventricles of the brain, the theca vertebralis, the pleura, and the pericardium (*The Morbid Anatomy of the Brain in Mania, Hydrophobia, &c.*); yet, when Dr. Magendie has opened the membranes of the brain or spinal marrow, I have myself seen a colourless clear fluid instantly escape.

one portion of the sac adhering closely to it, and one lying over this again; the internal surfaces of both portions are always in contact, because, if the parietes of the thorax expand and draw with them the external portion, the lung at the same time expands with air and forces forwards the internal in the same degree.

The union of the two pleuræ, from the sternum to the spine, is called the septum or mediastinum. The heart lies between the two. Before the two unite at the posterior part, they leave a cavity, called the cavity of the posterior mediastinum, containing the aorta, œsophagus, thoracic duct, vena azygos, large bronchiæ, lymphatic ganglia, and cellular membrane. In front, they leave another space, called the cavity of the anterior medastinum, which contains cellular membrane, and in the fœtus the thymus gland.

" The lungs hang, in a manner, from the wind-pipe, usually called aspera arteria or trachea," " which is composed of an internal mucous membrane continuous with that of the fauces, of an external fibrous membrane, and of from fifteen to twenty fibro-cartilaginous falciform arches, imperfect at the posterior part, where transverse muscular fibres connect the two extremities of each cartilage. Within this muscular coat, and throughout the trachea and bronchiæ, a coat of longitudinal fibres is seen.

" The aspera arteria, having entered the thorax, is bifurcated" (the right branch the shorter and wider) " opposite the third dorsal vertebra," " into the trunks of the bronchiæ, and these, the more deeply they penetrate into the lobes and lobules of the lungs, are the more and more ramified;" the fibro-cartilaginous rings are each divided into pieces, more and more numerous and smaller, till they are mere grains, and at length are lost, together with the external fibrous coat; and the extreme divisions, consisting of the mucous membrane, and probably of the circular longitudinal fibres immediately external to it, terminate in those *cells* which form the chief part of the substance of the lungs and alternately receive and emit the air we breathe.

" The shape and magnitude [f] of the air-cells are various. The former is generally polyedrical. The latter, in regard to surface, is scarcely to be defined [g]: though, indeed, the *capacity* of the lungs of an adult, during a strong inspiration, is about 120 cubic

[f] " Keil, indulging his luxuriant iatro-mathematical genius, assigned more than 1,744,000,000 cells to each lung."

[g] " Lieberkühn, with equal exaggeration, made the surface of the cells equal to 1500 square feet."

inches. The immense size to which the lungs may be inflated, when the chest has been opened, has no relation to our present subject.

"The cells are invested and connected by the common but delicate cellular membrane — the general vinculum of the body — and must be carefully distinguished from it. In healthy and very recent lungs, I have found the cells so unconnected that they were distended in one insulated spot by air cautiously inflated into a fine branch of the bronchiæ, while neither the neighbouring cells nor the cellular membrane, which lies between the cells, admitted the smallest portion. If air is forcibly thrown in, the air-cells are ruptured and confounded with the cellular membrane, and both parts distended.

"The cellular membrane surrounding the air-cells of the lungs is supplied with innumerable blood-vessels — divisions of the pulmonary artery and four pulmonary veins, the branches of which accompany the ramifications of the bronchiæ[h], and, after repeated division, form at length an immense collection of most delicate and reticulated anastomoses. This extraordinary network, penetrating the mucous web on every side, closely surrounds the air-cells, so that the prodigious quantity of blood existing in the pulmonary vessels is separated from the contact of the air by very fine membranes only, which Hales estimated as scarcely $\frac{1}{1000}$ of an inch in thickness.

"As each ramification of the bronchiæ possesses its own bunch or lobule of air-cells, so again each of these possesses a peculiar system of blood-vessels, the twigs of which anastomose in the wonderful network with one another, but scarcely at all with the blood-vessels of the other lobules, as is proved by microscopic observations on living frogs and serpents, by minute injections, and by the phenomena of vomicæ and other local diseases of the lungs."

The best treatise with which I am acquainted upon the lungs, is the prize commentary of Reisseisen, published by the Royal Academy of Sciences at Berlin in 1808, and printed in 1822, with six beautiful coloured engravings, and a Latin version, under the care of Professor Rudolphi.[i]

[h] "Eustachius, tab. xxvii. fig. 13."

[i] Francis Daniel Reisseisen, M.D. of Strasburgh, *über den bau der Lungen, eine von der Königlichen Academie der Wissenshaften zu Berlin gekrönte Preiss chrift*. Berlin, 1822.

He asserts, 1st, That the subdivisions of the bronchiæ occur more and more thickly, the twigs proportionally decreasing in diameter and length, and that each ultimate twig ends in a close bulbous extremity, or cell, communicating with other bulbous extremities only in an indirect manner, — by means of the twigs which end in them. Malpighi had described them as round, and mere dilatations in the course as well as at the ends of the bronchial twigs.[k] 2d, That, as Malpighi proved, and contrary to the subsequent opinion of Helvetius and others, these ramifications and cells have no connection with the surrounding common cellular membrane. 3d, That they consist of, — 1. *mucous membrane*, behind which lies, — 2. a coat of *elastic* white fibres, their existence being visible as far as the canals can be traced, and the regular discharge of any fluid injected into the bronchiæ after death proving the existence of elasticity in the bronchial ramifications; — 3. a coat of *muscular* fibres, transverse relatively to the course of the canals, and visible by the aid of a magnifier as far as the size of the canals will allow them to be traced. He conceives the muscularity of the twigs and cells to be shown also from the necessity for its existence in them no less than in the large trunks and trachea, where it is visible; from their evident contraction in the experiments of Varnier, who irritated them by the injection of stimulating liquids and gases, and by mechanically stimulating the surface of the lungs[l]; and from the circumstance of the lungs shrinking much more if an opening is made in the thorax of a living than of a dead animal, in the latter of which it can shrink from elasticity only. 4th, That the ramifications of the bronchial and pulmonary arteries freely anastomose both in the air-passages and on the surface of the lungs, and that the bronchial arteries run chiefly direct to the pulmonary veins. 5th, That the air-passages and blood-vessels of the lungs are most abundantly supplied with nerves from the par vagum, whose conjunctions with the sympathetic take place externally to the lungs.[m]

" The common membrane investing the lungs is the chief seat of a remarkable network of lymphatic vessels [n] which run to nu-

[k] *Epist. de Pulmon.* 1. p. 133.

[l] *Mémoires de la Société Royale de Médecine.* 1779. p. 394. sqq.

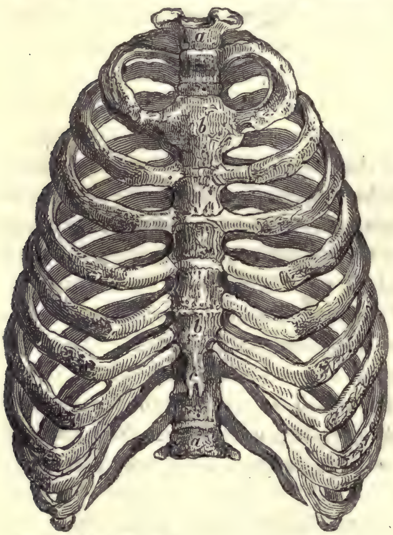
[m] Some other conclusions are drawn, but unimportant or unsatisfactory.

[n] " Mascagni, *Histor. vasor. lymphaticór.* tab. xx."

merous lymphatic or conglobate glands[o], carefully to be distinguished from a neighbouring order of glands, called bronchial, that are supplied with an excretory duct opening into the mucous membrane of the bronchiæ, and are of the conglomerate kind.[p]

"The *thorax*, which contains the lungs, has an osseous and cartilaginous framework," narrow above and broad below, "somewhat resembling a bee-hive, throughout very firm and stable, but in every part more or less movable for the purpose of respiration."[q]

The framework is the twelve dorsal vertebræ, forming a column convex externally, concave in front; the twenty-four ribs, also convex externally and concave within; and the sternum: all the ribs are united at one extremity by a joint with the dorsal vertebræ; the seven highest ribs are connected at their other extremity with the sternum by means of a cartilage, larger and longer in each lower rib, just as each of the seven ribs is longer than the rib above it (true or sternal ribs), and the three next are each united by cartilage with the cartilage of the rib above (false or asternal ribs), and the two lowest have their anterior extremity unattached (floating false or asternal ribs). When the



a, vertebræ of spinal column.
b, sternum.
c, ensiform cartilage.

[o] "Ibid. tab. xxi."

[p] "Consult Portal, *Mém. de l'Acad. des Scienc. de Paris.* 1780."

[q] "J. G. Amstein (Præs. Oetinger), *De usu et actione musculor. intercostal.* Tubing. 1769. 4to. Theod. Fr. Trendelenburg, Jun. *De sterni costarumque in respiratione vera genuinaque motûs ratione.* Gotting. 1779. 4to.
Bordenave and Sabatier, *Mém. de l'Acad. des Scienc. de Paris.* 1778."

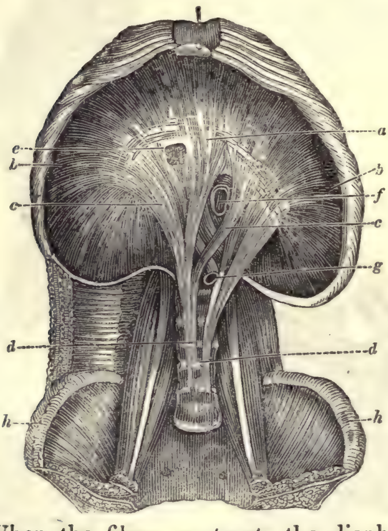
ribs are raised, their vertebral extremity rotates, remaining in its place; the rest of the rib rises, each part of course the more, the more distant it is from the vertebra, and the lower margin is drawn rather outwards; and with the ribs the sternum rises. The chest thus becomes both *broader* and *deeper* from front to back.[r]

"Between the edges of the ribs lie two strata of intercostal muscles, differing in the direction of their fibres, but conspiring" to elevate the ribs or depress them, just as the higher or lower rib happens to be the more fixed. The one is external, placed between the vertebræ and the cartilages, and its fibres run forwards and downwards: the other internal, placed between the sternum and the angle or curve of the rib near the spine, and its fibres run downwards and backwards. Ordinarily, they act as muscles of inspiration, and raise the ribs, because the lower rib is more movable than the one above it.

Between the higher and middle rib, except near the sternum, is seen the internal intercostal: between the lower and middle, the external.

[r] Although each lower rib among the first eight must execute a greater extent of motion, from being longer than the one above, yet the first is asserted by Dr. Magendie to be absolutely more movable than the second, the second than the third, &c.; and this because the first has but one articular surface, is articulated with but one vertebra, and possesses neither internal nor costo-transverse ligament, and has the posterior ligament horizontal, and because slight shades of difference exist in the disposition of the ligaments of the six other ribs. *Précis Elémentaire*, t. ii. p. 317.

"At the base of the thorax, the diaphragm [s] is subtended in the form of an arch." The central part is tendinous, and has an irregularly quadrilateral opening rather to the right, for the transmission of the vena cava, which adheres to its margin and is thus kept open. From this tendinous centre, muscular fibres proceed in all directions, and the anterior and lateral are inserted into the ensiform cartilage and six lowest ribs and their cartilages, while the posterior fibres converge into two great bands, called pillars of the diaphragm, which run downwards and are inserted by means of two tendons into the three first lumbar vertebræ. At their origin they leave an oval opening between them for the passage of the œsophagus and pneumo-gastric nerves, each bunch sending a bundle across to the other in order to complete the opening behind. More posteriorly, near their termination in tendon, they leave a parabolic opening for the aorta, vena azygos, and thoracic duct.



a, central tendon.
b, surrounding muscle.
c, crura.
d, tendons of crura.
e, opening for vena cava.
f, opening for œsophagus.
g, space for aorta.
h, ossa *ilii*.

When the fibres contract, the diaphragm descends, chiefly at its sides, and ceases to be vaulted, and the cavity of the chest *lengthens*. It is the lateral portions only which in ordinary inspiration sensibly descend.

[s] "Haller, *Icon. Anat.* fascic. 1. tab. i.
B. S. Albinus, *Tab. musculor.* tab. xiv. fig. 5, 6, 7.
J. G. Röderer, *De arcubus tendineis muscul.* progr. 1. Gotting. 1760. 4to.
Santorini, Tab. Posth. x. fig. 1."

"It is a considerable muscle, and, in the words of Haller, next in importance to the heart. Its utility in the mechanical part of respiration was long since shown, by the excellent experiments of Galen [t] upon living animals, to depend chiefly on the phrenic nerve.[u]

"Its antagonists are the abdominal muscles, especially the two sets of oblique and the transverse.

"The thorax, thus constituted, is, after birth, dilated by inspiration, and subsequently reduced to a smaller capacity by expiration.

"During the former act, the thorax is enlarged laterally and inferiorly, so that the bodies of the six ribs mentioned above are elevated and their inferior margin drawn somewhat outwards; the arch of the diaphragm is at the same time rather depressed and flattened."

The lungs in ordinary respiration do not descend lower than the sixth rib, and the lateral portions of the diaphragm, ascending into the empty space, lie in contact on both sides with the lower ribs, each covered by its costal pleura.

Dr. Carson gives the following account of the mechanical part of respiration.

The substance of the lungs is highly elastic, and constantly kept in a forced state of distension after birth by the pressure of the atmosphere.[x] This is evident also from the lungs collapsing upon our puncturing the walls of the thorax, — a circumstance arising from the atmospheric pressure on the one hand becoming counterbalanced on the other, so that their elasticity, experiencing no opposition, becomes effective.[y] During inspiration, the intercostal muscles raise and draw out the ribs, and the diaphragm descends: the enlargement of the thoracic cavity is instantly followed of necessity by the greater distension of the substance of the lungs from the diminished resistance to the atmosphere gra-

[t] "*De Anatomicis Administrationibus*, l. viii. cap. 8. The whole book is very rich in experiments on respiration."

[u] "Ephr. Krüger, *De nervo phrenico*. Lips. 1759.; reprinted in Sandifort's *Thesaurus*, tom. iii.

Walter, *Tab. nervor. thorac. et abdominis*, tab. i. fig. 1. n. 1."

[x] See Haller, *El. Phys.* lib. viii. s. iv. pp. 259. 275.

[y] Dr. Carson found the elasticity of the lungs of calves, sheep, and large dogs balanced by a column of water of from a foot to a foot and a half in height, and of rabbits and cats by a column of from six to ten inches. *Phil. Trans.* 1820. Part 1.

vitating in the bronchiæ. The diaphragm and intercostal muscles ceasing to act, the substance of the lungs exerts its elasticity with effect, recovers its former dimensions, and drives out the additional volume of air just admitted, and the passive *diaphragm* follows the shrinking substance of the lungs, offering, from its relaxation, no resistance to the atmosphere pressing on the surface of the abdomen. Thus expiration is produced. The muscular power of the diaphragm and intercostal muscles is far greater than the elastic power of the lungs, and therefore, when exerted overcomes it, producing inspiration : but, ceasing to be exerted, the elastic power gains efficiency, and produces expiration.

To the elastic, Reisseisen adds the muscular, contraction of the bronchial ramifications and cells. " Thorace ampliato, aër vacuum in pulmone spatium occupat, *victisque fibris*, fistulam spiritalem quaquaversum extendit, ultra modum, quo quiescit, explicari coactam, unde fibræ *elasticæ resilire*, circulares sese contrahere nituntur, quo fit ut desidente thorace omnes simul ad expellendum spiritum vires intenduntur. Sunt autem, thoracis undique desidentis pressio, tum fibrarum fistulam spiritalem in brevius contrahentium vis *elastica*, denique *muscularium* illam constringentium *irritabilitas*.

" The contractile power of the diaphragm (*and intercostal muscles*), in conformity with the laws of muscular motion," says Dr. Carson [z], " is irregular, remitting, and sometimes altogether quiescent. The elasticity of the lungs, on the other hand, is equal and constant. The superior energy of the former is balanced by the permanency of the latter. By the advantage which the inferior power, from the uniformity of its operations, is enabled to take of the remissions of its more powerful antagonist, the ground which had been lost is recovered, and the contest prolonged; that contest in which victory declaring on one side or the other is the instant death of the fabric."

In the common account of respiration, the elasticity and muscularity of the lungs are unnoticed, and expiration is ascribed to the elasticity of the cartilages of the ribs, and to the contractions of the abdominal muscles emptying the lungs by pressure. Now, according to Dr. Carson, in the first place, the elasticity (*and muscularity*) of the lungs is of itself sufficient for the purpose ; in

[z] l. c. p. 223.

the second, there is no proof of the agency of the abdominal muscles in expiration; it proceeds equally well in cases of inanition, when their contraction would rather enlarge than diminish the abdominal cavity, and in experiments when they are entirely removed from animals, — a child was born without them, and had lived eighteen months at the time of the publication of its case, and was very well[a]: and I may add, thirdly, that, although the elasticity of the cartilages of the ribs must conspire with that of the lungs, numerous cases are recorded of immobility of the ribs, by ossification of their connections, where respiration was not materially impeded.[b] These cases are adduced to show that the diaphragm is the chief instrument of respiration; but, as its elasticity cannot produce expiration, they show that this was accomplished entirely, or in a great measure, by the lungs themselves. Even where there is no ossification, the motion of the ribs has very little share in respiration; and Dr. Bostock considers the chief use of the intercostals to be that of giving a fixed point for the action of the diaphragm, and the operation of the abdominal muscles in expiration to be nearly passive.[c] It is commonly known, however, that, if the pleura is wounded, air rushes into the chest during inspiration only, and is in some measure expelled again during expiration. Galen showed this, notwithstanding his object was different, by wounding the chest and fixing a bladder upon the wound. The bladder shrunk at inspiration, and became distended at expiration.[d] Were the ascent of the diaphragm and descent of the ribs in expiration the *effect* of solely the contraction of the lungs — of a tendency to vacuum occasioned by their shrinking, — air and fluids should stream to the chest as much during expiration as inspiration — should rush to fill up the vacuum as much as the diaphragm should ascend and the ribs descend for that purpose: nor should air be expelled from the wounded pleura; for we may regard the thoracic cavity

[a] *Gazette de Santé*, Dec. 5. 1826. A child of seven years is *said* in Lieutaud to have had no diaphragm.

[b] Dr. Bostock, *An Elementary System of Physiology*, vol. ii. p.15.

[c] l. c. vol. ii. pp. 7. 15.

[d] *Administ. Anat.* lib. viii. c. ult.

If, instead of a bladder, a tube immersed in a coloured fluid is employed, this will of course rise in inspiration, and remain stationary or fall in expiration. See *Experimental Researches on the Influence exercised by Atmospheric Pressure upon the Progression of the Blood in the Veins, &c.* By Edward Barry, M.D. London, 1826.

as bounded above by the surface of the lungs, and always in the sound state possessing the same dimensions, — the expansion of the lungs being commensurate with the descent of the diaphragm and ascent of the ribs, and the descent of the diaphragm and ascent of the ribs commensurate with the shrinking of the lungs. The fact that air does not stream into the wounded pleura in expiration, but even streams from it, while the ribs are moveable and the abdominal muscles active, proves, I think, that the descent of the ribs and ascent of the diaphragm, one or both, in ordinary expiration, do partly occasion, by compression[e], the diminution of the lungs, or, at least, are not its passive effect, but coincide with it by independent powers,—which are, the elasticity of the elevated ribs (and displaced abdominal organs ?), if not the contraction of the extended abdominal muscles. We shall presently see another reason for believing that the organs of the chest are really compressed during expiration. Haller refers expiration to the pressure of the lungs by the elastic ribs and the abdominal and other muscles, and to the elastic and muscular contraction of the lungs themselves, which he considers more forcible than the compression. It appears to me that he is right; but that, nevertheless, either the lungs alone, or the walls of the chest alone, are able, when unassisted by the other, to produce expiration. The change in the situation of the ribs is, moreover, trifling compared to that of the diaphragm, and respiration often proceeds very well by the diaphragm alone. Animals which are remarkable for swiftness and perseverance in the race scarcely employ the intercostal muscles, using the diaphragm almost solely.[f]

The beautiful contrivance in the shape of the thorax deserves attention. By its being conical, every degree of motion in the diaphragm produces a greater effect on the capacity of the chest than could occur were it of any other shape.

The passage of the air into and from the cells may be distinctly heard on applying the ear to the corresponding part of the chest, and is called by Laennec the respiratory murmur. It is much louder in children, and in them the cells are far more numerous and small. Whence an equal portion of lung from an infant a few days old weighs fourteen times more than from a man of seventy.[g] When the air tubes are constricted or supplied with too copious

[e] l. c. lib. viii. sect. iv. p. 275. sq.

[f] Dr. Carson. l. c. p. 226. In disease I have seen the diaphragm regularly relax when the intercostals contracted, and contract when they relaxed. Any one may readily make them act oppositely.

[g] Dr. Magendie, *Journal de Physiologie*, t. i. p. 81.

or with diseased secretion, the respiration is heard with various sounds, rough and snoring (sonorous rattle), shrill, squeaking, chirping, hissing (sibilant rattle), gurgling (mucous rattle); and, if too much fluid exists in their extremities or the air-cells, we hear a crackling sound (crepitant rattle). If the tubes are quite obstructed, or the lung compressed by air or fluid in the pleura, or by a solid, or if they are solidified, we hear no respiratory murmur. In the three latter cases, the walls of the chest, when struck at the spot affected, do not give out the hollow sound which the presence of air in the lungs naturally gives, but are as dead as if any solid muscular part was struck. These and many similar facts, discovered by Avenbrugger [h] and Laennec, are of the highest utility in detecting diseases of the chest, exist by physical necessity, and, being facts, are just as important to the medical philosopher as any other symptoms ; and though some, who have contrived to acquire a name among the ignorant, may affect to despise them, the rising generation feel justified in ascribing their contempt to indolence, conceit, and ignorance—an ignorance so disgusting, that it must eventually reduce them to their proper level.

The elasticity and muscularity of the lungs are not sufficiently great to expel the whole of their air in expiration. Thus they remain constantly in a certain degree of distension. [i]

I now recur to the subject of the circulation of the blood, as promised in the last chapter.

The vacuum constantly threatening in the chest, according to Dr. Carson, either from the shrinking of the lungs or the contraction of the inspiratory muscles, and, I may add, from the expulsion of blood from the ventricles of the heart, will evidently be prevented, not only by the falling of the ribs and the ascent of the diaphragm in the former case, and ingress of additional air into the bronchiæ in the latter, but also by the flow of venous blood into the auricles: for the venous blood, being subject to the full atmospheric pressure without the chest, will necessarily be driven into the chest to prevent a vacuum [k] ; the blood of the

[h] *Inventum novum ex percussione thoracis humani, abstrusos interni pectoris morbos detegendi.* 1761.

[i] Reisseisen, l. c. p. 23.

[k] See Dr. Huxham. *Observationes de Aëre et Morbis Epidemicis.* Londini, 1751. Prolegomena, p. 7. sqq. "Facto nempe in ductibus pulmonum sanguineis mo-

pulmonary artery and aorta is under the same circumstances, but the propelling force of the ventricles at one moment, and the action of their valves during their relaxation, prevent its retrogression. The atmospheric pressure on the blood-vessels creates a necessity for greater strength in the ventricles, as it impedes the progress of blood from the heart; but it also facilitates the return. Thus the smaller pressure on the heart acts, by the intervention of the blood, as an antagonist to its contracting fibres, assisting to dilate them when they become relaxed.

That the blood is drawn towards the heart during inspiration has been long acknowledged. "In my experiments," says Haller, "if you open the chest, abdomen, neck, or fore-extremities of an animal, and lay bare the great veins, the superior and inferior cava, the jugular, subclavian, brachial, or mammary, you will see the blood return to the heart *whenever the animal inspires*, and these veins recede some lines from it, become empty and pale, flat and bloodless:" — depleri, palescere, explanari, exsangues fieri."[l] In the words of Dr. Magendie, sixty years afterwards [m], "when the chest dilates, it inspires the blood of the cavæ, and successively that of the veins ending in them, much in the same way as it does the air into the trachea." Were Dr. Carson's account of expiration correct, as a vacuum would be

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mentaneo quasi vacuo, continuò in cor dextrum impellit sanguinis quantum facile capit pondus atmosphæræ." Quoted by Dr. M. Hall.

[l] l. c. lib. vi. sect. iv. p. 333. 1760.

[m] *Journal de Physiologie*, t. i. p. 136. 1821. For the same reason, if a tube is placed in the jugular vein, the air rushes into it during respiration with a noise, and the ill effects of air in the heart occur. (Magendie, l. c. p. 195.) And if a large vein is opened in surgical operations, and any thing prevents the sides from collapsing, the air may rush in and destroy life, as happened a few years ago at Paris. (l. c. p. 192. sqq.) This may be shown also, by inserting a tube, immersed in a coloured fluid, into a large vein, when the liquid will rise during inspiration, and stop or descend during expiration. (See Sir D. Barry, l. c. who conceives another source of vacuum to the pulmonary veins and venous sinuses, by the distraction of their parietes during inspiration, p. 29. 1826. And *Dissertation*, &c. p. 13. sq.) Still more recently, Sir D. Barry has applied the barometer to the chest of a pigeon, a viper, a common snake, and a frog, and found the mercury descend during inspiration. When connected with the exterior of the pericardium of an eel, the mercury became concave each time that the heart retired from the pericardium, so that its pulsations could be counted, and also at every effort of the animal to open its gill covers. *Sur l'Application du Baromètre, &c.* *Annales des Sciences Naturelles.* Avril, 1827.

threatening in the chest equally during expiration and inspiration, the shrinking of the lungs should occasion the blood to stream towards the heart as much during the one as the other, to fill up the vacuum. But this is not the fact, any more than, as we saw, that air rushes into the wounded pleura during expiration. The coincidence of the effect of inspiration on the venous blood, and, when the pleura is wounded, on the air, prevents us from supposing that inspiration affects the circulation merely by giving a free passage of blood through the lungs. "The great venous trunks of the head, neck, chest, abdomen, fore-extremities," says Haller, "swell *during expiration*, from the blood either being obstructed or retrograding, and at inspiration are emptied of it from its flowing freely to the heart."[n] Or, in the words of Magendie, "when the chest contracts, the blood is driven back into the cavæ by the pressure experienced by all the organs of the chest." That the blood does really retrograde during expiration, appears by an experiment of Magendie's, in which a hollow bougie was passed into the great veins as far as the cava, or auricle itself, and the blood flowed from its extremity during expiration.[o] This fact seems to show compression of the thoracic organs during expiration, and therefore is an additional argument that ordinary expiration is not the effect solely of the elastic and muscular shrinking of the lungs. Such, indeed, is the pressure of expiration, that the heart during it propels the blood more violently into the arteries, and even into the veins; and, on the other hand, less forcibly during inspiration.[p] A continuance in refrain-

[n] l. c. ibid. [o] *Journal de Physiologie*, t. i. p. 186. Paris, 1820.

[p] Bordeu, *Du Pouls*, p. 324. quoted by Haller; and Bichat, *Recherches Physiol.* p. 223. See Magendie for the veins, *Journal de Physiol.* t. i. p. 138., and Tulpius, *Obs. Med.* ii. 3. p. 106. In violent efforts the chest is still more compressed, whence the blood accumulates without the heart in the veins, and is driven more forcibly from the heart to all parts. These may be made after expiration or inspiration; but for a very violent effort we usually inspire first, to afford a better fixed point, and to continue the effort longer than would be possible after expiration. Respiration is generally suspended and the glottis closed; but if the effort is made after an inspiration, the glottis need not be closed, provided the air is allowed to leave the chest very slowly.

In myself, a deep inspiration, not followed in due time by an expiration, causes the pulse in a few seconds to become suddenly slow for a few seconds, falling as much as five and twenty beats per minute, and even double this, if it has just become rapid by a deep and prolonged expiration: but, as the breath continues to be held, which may be done much longer than inspiration can be refrained from

ing to inspire after a violent expiration, of course almost suspends the circulation, by depriving the heart of blood [q], which is no longer drawn to the heart by inspiration, and has been squeezed out by expiration: a continuance in refraining to expire after a deep inspiration has the same effect, but more slowly. In both cases the blood is no longer drawn to the heart by inspiration, and does not experience those chemical changes in the lungs which are indispensable to its free passage through them; though, they being, in the former, filled with air, and empty in the latter, it can continue to pass through them much longer in the former.

And this leads me to observe, that the mere suspension of respiration impedes the circulation through the heart, by causing obstruction in the lungs; and that, consequently, inspiration, by giving free passage to the blood through those organs, will accelerate its course through the veins, independently of a vacuum; although the influence of the vacuum is shown by the effect of inspiration upon the contents of tubes inserted, not into the veins, but merely into the cavity of the pleura or pericardium. Whether respiration is suspended after an expiration or an inspiration, the effect is the same: — the blood accumulates in the lungs and right side of the heart, if the windpipe is tied, whether the lungs be empty or full at the time of the ligature; and therefore it is not merely the mechanical condition of the lungs that produces the obstruction in this case, as was once supposed, but the want of chemical changes.[r]

But for this consideration, the effects of the thoracic vacuum on the circulation might be overrated; and, indeed, that too high an estimate has been formed of it is very certain: for,

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after expiration, as there is a supply of air in the lungs in the former case, and not in the latter — (in the latter I can refrain for a quarter of a minute, and in the former for rather above a minute) — the pulse gradually resumes its former quickness; and, when the breath can be held no longer, evidently grows more and more rapid and weak. The effects of refraining from expiration are the same in me as of refraining from inspiration. Rapid respiration quickens the pulse, by drawing the blood more frequently to the heart; and, in my case, if very deep as well as rapid, the circulation through the head becomes so violent that vertigo occurs, and, between this and the rapidity of the pulse, I at length cannot count the latter.

q My own pulse, if a deep expiration is made, and inspiration refrained from, becomes rapid and excessively feeble, and more and more so till I can hold out no longer.

r See Haller, l. c. lib. vii. sect. iv. p. 253.

1. In the fœtus, and in animals which do not respire at all, or not by a thoracic vacuum, the vacua arising from the dilatation of the heart's cavities, and from its diminished bulk under contraction, only can occur.[s]

2. If we suspend respiration and prevent the influence of both sources of vacuum, the circulation continues till the want of chemical changes arrests it; and, if the vena cava, or any great vein, is obstructed so as to cut off connection with the heart, it becomes distended with blood[t] coming up towards the heart; and, if wounded between the ligature and the extremities, the blood flows, whatever the position of the animal, till death ensues.[u] In these cases no vacuum assists. If the pericardium is laid bare, so that no vacuum can occur, except that from the dilatation of the heart's cavities, and the trachea tied, the right ventricle swells enormously with the arriving blood[v],—a fact not to be explained by vacuum, not even by the heart's own vacuum. The influence of the left ventricle upon the course of the blood in the veins was also shown by Magendie, who firmly tied every part of a dog's leg, except the great artery and vein, and then tied the latter and wounded it below the ligature, when the blood was projected to some distance, and continued to be so, except when the artery was compressed; and, as long as the circulation continued, the stream from the vein was regulated at pleasure by compressing or liberating the artery.[x] If a turgid vein in the hand is compressed, it will not become empty above, as it should if suction from one or all of the three sources mentioned were considerable; and the jet of blood from an artery was found by Hales to be greater during a deep inspiration[y], (probably from the more abundant supply to the left side through the lungs), showing the action of the ventricle to be proportionably greater than the power of the thoracic vacuum at the moment of inspiration to oppose the discharge of blood from it. Still the effects of the vacuum are such as we have seen.

[s] On connecting the barometer with the interior of the pericardium of an eel, Sir D. Barry found the mercury move.

[t] Hunter, *On the Blood,* p. 75. sq. Haller had previously ascertained the same thing, and, while allowing the influence of a vacuum, urged it as a proof, that the vacuum was not efficient, but only auxiliary. *El. Physiol.* t. ii. p. 325.

[u] Mr. Spry, *Lancet.* Jan. 1827.

[v] Dr. David Williams, *Edinb. Med. and Surgical Journal,* 1823, p. 528.

[x] *Journal de Physiol.* t. i. p. 111.

[y] *Statical Essays,* vol. ii. p. 6.

The empty condition of the arteries after death has been ascribed by Dr. Carson to the thoracic vacuum. He states that, if an animal is destroyed by admitting air into each pleura, the arteries are found as turgid as the veins[z]; but the same results have not been obtained by others[a]; and I presume that the obstruction in the lungs from the want of chemical changes, gradually lessening the supply to the arteries, and producing accumulation in the veins, together with the superior contractile powers of the arteries, are, jointly, quite sufficient to explain the circumstance. The effect of the obstruction in the lungs, while the left ventricle continued to propel blood, was strikingly shown by Bichat, who produced enormous congestion of the lungs, liver, spleen, &c. by strangling animals slowly, and found much less if respiration was completely arrested at once, so that the left ventricle ceased to propel blood very soon after the obstruction in the lungs took place.[b] The greater the space into which the former blood can flow from the arteries, the less blood will they contain. Hence, if a ligature is passed round the cavæ, some quantity of blood is found in the arteries; if around the pulmonary artery, less; and, when the lungs have been kept distended after death by artificial inflation after opening the chest, so that all their vessels might be unfolded, the arteries have been found quite empty, though there was no thoracic vacuum[c], and though the effect of the left ventricle of the heart was destroyed by a ligature on the aorta.

Therefore, if Dr. Carson's experiments on this point are accurate, I should ascribe the turgidity of the arteries when the pleuræ were filled with air, and the lungs compressed, to the diminution; and when this was not done, the emptiness of the arteries, to the largeness, of the pulmonary space into which the blood could pass.

The influence of suction has been thought by Dr. Carson to assist in explaining absorption.[d]

Dr. Carson ascribes the effects experienced in elevated situations to the rarity of the atmosphere, by which it cannot compress the blood sufficiently to aid the return of this fluid towards the heart. Saussure[e] says, that when he was on the summit of the Alps he experienced extreme fatigue and loss of muscular power,

[z] *Med. Chir. Trans.* vol. xi.

[a] Dr. Fennel, *The Philadelphia Journal*, Nov. 1822.

[b] *Recherches Physiologiques*, p. 225. sq.

[c] Mr. Robert Hunter, *Edinburgh Journal*, Oct. 1824.

[d] l. c. p. 167.

[e] *Voyage dans les Alpes.*

and irresistible, rapid, and violent palpitation, and difficulty of breathing, all which soon ceased on his assuming the horizontal posture, in which, of course, the blood circulates more easily. His guide, a slim old man, was unaffected, and climbed with ease like a goat, and many unaccustomed to such elevations have been equally unaffected; for habit or a strong heart will render the influence of pressure but little necessary.

Gravity has been thought by Dr. Carson, as well as by older writers, materially to aid the circulation:—"By the stroke of the heart, a quantity of fluid is withdrawn from one end of the column, and by the synchronous vibration of the arteries an equal quantity is added to the other." "A perpetually repeated generation of motion must be produced through the different parts of the venous system by gravity, and this motion must be from the ends of the veins to the trunks."[f] "The simplest weight of a column of blood in any descending artery is sufficient to raise the blood through open capillaries to an equal height in the corresponding vein, according to the hydrostatical law, that fluids attain the same level in all communicating vessels."[g] Yet, in the horizontal posture, there can be no assistance from gravity, but the circulation proceeds perfectly well: and, indeed, gravity, on the whole, seems to impede the circulation; for, if the arms hang down for a length of time, or the legs are not rested horizontally, they ultimately swell. Nothing assists the heart more than a horizontal posture, as seen in syncope, in which the restoring agency is perfectly explicable by its mechanical aid to the heart, without reference to the brain.[h] The effects of posture are necessarily greater in tall persons. In the horizontal posture, the heart, having less to do, beats more slowly, and in very tall persons the pulse has been found 12 or 20 beats quicker in the upright posture.

The operation of exercise is very material. If an extremity is not exercised, its circulation always becomes languid, it resists external temperature with difficulty, and wastes; and, if gravity also co-operates by a vertical position, it swells; and exercise will prevent the congestive agency of a continued vertical position. Violent exercise causes proportionate violence of circulation. The action of muscles evidently operates by compression, and chiefly of the veins, as the coats of the arteries are so much stronger. The

[f] l. c. p. 138. sq.

[g] *Elements of Physics.* By N. Arnott, M.D. Lond. 1827. p. 500.

[h] See Bichat, l. c. p. 198. sqq.

blood can go but one way. The stream behind, and the valves in the veins of the extremities, determine the effects of the pressure to be in the course of the circulation. The compressed vessels are at once nearly emptied, and the instant that the pressure is alternately removed are again filled; and the momentary impediment during the compression is immaterial, on account of the innumerable venous anastomoses. The progress of the blood cannot but be accelerated. The dyspnœa that is felt arises from the force with which the blood drives through the lungs, and which renders frequent respiration necessary.

In the fœtus the case is analogous, although Dr. Carson has imagined it different, and thought it necessary to frame a little hypothesis to reconcile circumstances. The fœtal lungs, experiencing no atmospheric pressure, are contracted to the utmost, and the diaphragm, suffering no stimulus from the will on account of uneasy sensation arising from want of breath, is completely relaxed, and forced upwards to remove the vacuum; and the venous blood without the thorax must be drawn forcibly into the right auricle, preventing the vacuum which the discharges of blood from the left ventricle tend to produce. In the fœtus, moreover, the blood is propelled into the aorta by *both* ventricles, as Mr. John Bell remarks, and, therefore, the circulation less requires other assistance. The vacuum from the dilatation of the cavities of the heart occurs in the fœtus and all animals which have a heart: but, in those which have no such respiration as the human, there can be no assistance to the circulation by *thoracic* vacuum.

The ordinary cause of the first inspiration appears to be the novel impression of cool air upon the surface; for, if at any time we are suddenly exposed to a cold wind, or plunge into cold water, the diaphragm and intercostal muscles instantly contract, and a sudden *inspiration* takes place. The blood rushes into the expanded lungs, and, being afterwards obstructed when the inspiratory muscles cease to act, and the elastic lungs shrink, gives rise to an uneasy sensation, which is instinctively removed by another inspiration, and thus respiration afterwards continues through life. The fact of respiration commencing before the chord is tied, shows that neither congestion in the aorta, nor deficiency of chemical changes, is the cause of the first inspiration. If an animal is born under warm water, its respiration begins at the moment you choose to bring it up into the air. Buffon proved this by causing a bitch's delivery to take place in a tub of warm water, and allowing the pups to remain there for half an hour.

The power of excitement of the surface to cause inspiration has been shown by Beclard and others, who, on mechanically irritating fœtal kittens still enclosed in the membranes, found inspiratory efforts take place at each irritation.

" The alternate motion of the chest continues, during health and freedom from restraint, from the moment of birth till death. Its object is, that the lungs may be expanded to admit the air, and contracted to expel it, in perpetual alternation. This alternation occurs, in an adult at rest, about 14 times in a minute,— once to about five pulsations of the heart." [i]

" For man, in common with all warm-blooded animals, cannot long retain the inspired air, but is compelled to discharge it and take in a fresh supply of this pabulum of life, as it always has been denominated. [k] Common observation teaches, that, however pure may be the air entering the lungs, it instantly undergoes remarkable changes, by which it is contaminated and rendered unfit for another inspiration, unless it is renewed. [l]

The common quantity of air taken in at each inspiration is about 16·5 cubic inches; and the quantity remaining after death in the lungs of a stout adult man, about 100 cubic inches, according to Allen and Pepys. Dr. Bostock, agreeing with Dr. Menzies and many others, believes 40 cubic inches to be the average inspir-

[i] But this varies in different individuals, and in disease. When there is disease of the heart, with excitement, the proportion of the heart's action is greater than natural; and where of the lungs or pleura, the proportion is on the side of respiration. But the action of both the heart and respiratory organs is increased in the affections of either. I have at this moment a young female patient, in whom, through a nervous affection, I always find the respirations 98 and the pulse 104. My clinical clerk says he has found the respiration 106 and the pulse 104. The inspirations are shallow. She is in no danger. The quickest pulse I have ever felt has been 208, counted easily at the heart, though not at the wrist. In the two middle-aged men in whom I observed this, there was merely morbid irritability of the heart, and they walked about and ate like other people, though indisposed. One is now very well.

[k] " The antiquity of the notion that air is the *pabulum vitæ* is seen in the book *de Flatibus,* usually ascribed to Hippocrates. The author regards the aliment as threefold,—victuals, drink, and air; but the latter he calls *vital,* because we cannot, for a moment, dispense with a supply of it without danger to life."

[l] " Consult Harvey's Dispute upon the necessary renovation of the aërial *succus alibilis,* with the celebrated Astronomical Professor, J. Greaves, in the latter's *Description of the Pyramids in Egypt,* p. 101. sq. Lond. 1646. 8vo.

Also the popular Edm. Halley's immortal *Discourse concerning the Means of furnishing Air at the Bottom of the Sea in any ordinary Depths.* — *Phil. Trans.* vol. xxix. No. 349. p. 492. sq."

ation, and thinks that 160 or 170 remain in the lungs after ordinary expiration [m]; for these organs are never emptied by expiration.

"It may be asked, what are the changes which the air experiences during inspiration, and which consist not in the loss of elasticity, as was formerly imagined, but in the decomposition of its elements. [n] For the atmospheric air which we breathe, is a peculiar mixture of constituents, differing very much in their nature from each other; and, not to mention heterogeneous matters, such as odorous effluvia, various other besides aqueous exhalations, and innumerable other substances, which are generally present, is always impregnated with aqueous vapour, electric and magnetic matter, and generally with carbonic acid gas; and is itself composed of unequal parts of two aëriform fluids, viz. 79 of azotic gas, and 21 of oxygen gas in 100.

"In the first place, we know for certain, that, at every inspiration (the fulness of which varies infinitely in different persons of the same age, breathing placidly [o]), besides the quantity of azotic gas being somewhat diminished [p], the oxygen gas is in a great measure converted into carbonic acid gas or fixed air; so that the air of expiration, if collected, instantly extinguishes flame and live coals, precipitates lime from lime-water, and is specifically heavier than atmospheric air, and rendered unfit for inspiration [q]; it also contains much aqueous vapour, which is condensed in a visible form by a temperature not exceeding 60° of Fahr." [r] The ordinary quantity of aqueous vapour emitted by

[m] *An Elementary System of Physiology*, vol. ii. p. 24. sq. Dr. Thomson thinks the estimate of Menzies most correct. *System of Chemistry*, vol. iv.

[n] "Fr. Stromeyer, *Grundriss der theoretischen Chemie*, P. ii. p. 619.

[o] "Consult, *v. c.* Abildgaard, *Nordischen Archiv. für Naturkunde*, &c. t. i. P. i. and ii."

[p] "Consult, besides, Priestley and others, especially C. H. Peaff, ib. t. iv. P. ii."

[q] "To discover how frequently an animal could breathe the same portion of the different kinds of air that we have mentioned, I took three dogs equal in size and strength, and to the trachea of the first, by means of a tube, I tied a bladder, containing about 20 cubic inches of *oxygen* gas. He died in 40 minutes.

For the second, the bladder was filled with *atmospheric* air. He died in six minutes.

For the third, I employed the carbonised air last expired by the second dog. He died in four minutes.

The air of the bladder, upon subsequent examination, gave the common signs of carbonic acid gas.

The instruments which I employed are described and illustrated by a plate in the *Medic. Biblioth.* vol. i. p. 174. sq. tab. I."

[r] "J. A. De Luc, *Idées sur la Météorologie*, tom. ii. pp. 67. 229."

the lungs, trachea, throat, and mouth, may be about 20 oz. in 24 hours.[s] It is probably derived from the chyle, and by the separation of so much water, the *weak* and delicate albumen of the chyle is converted into the *strong* and perfect albumen of the blood.[t]

" There is, consequently, no doubt that the carbonic acid of the expired air is derived from the venous blood carried to the lungs from the right side of the heart.[u] But it has been of late disputed, whether the inspired oxygen goes wholly to form carbonic acid in the bronchial cells[v], or whether it is in part united with the arterial blood and distributed through the arterial system.[x] Many weighty arguments seem to favour the latter opinion, as well as the phenomena of both kinds of blood in the living body[y], compared with the changes which this fluid experiences when exposed to these two kinds of air."

After much uncertainty, it was thought ascertained by the experiments of Messrs. Allen and Pepys that no oxygen is absorbed in ordinary respiration, but that what disappears goes entirely to unite with the carbon of the blood and produce carbonic acid, the latter being exactly equal in bulk to the oxygen which disappears, — about $27\frac{1}{2}$ cubic inches per minute, or 39,534 in twenty-four hours, according to the experiments of these gentlemen, — a quantity containing about 11 oz. troy of solid carbon, more than equal to the carbon contained in 6 lbs. of beef[z], and, perhaps, about double the average result of most other experiments.

[s] See Hales. See also chapter on Perspiration.

[t] Dr. Prout, l. c. p. 525.

[u] " Rob. Menzies, *De Respiratione*. Edinb. 1790. 8vo.

H. G. Rouppe, on the same subject. Lugd. Batav. 1791. 4to.

J. Bostock, *Versuch über das Athemholen. übers. von* A. F. Nolde. Erf. 1809. 8vo."

[v] " W. Allen and W. H. Pepys, *Phil. Trans.* 1808, p. 249. and 1809, p. 404. But how various the quantity of carbonic acid gas expired is, at different times of the day, and under different circumstances, is shown by the experiments of W. Prout, in Thomson's *Annals of Philosophy*, vol. ii. p. 328."

[x] " Nasse, in J. F. Meckel's *Archiv. für die Physiol.* vol. ii. p. 200.

And G. Wedmeyer, *Physiologische Untersuchungen über das Nervensystem und die Respiration*. Hanov. 1817. 8vo. p. 175."

[y] " J. Andr. Scherer, *Beweis, dass* J. Mayow *vor* 100 *Jahren den Grund zur antiphlogistischen Chemie und Physiologie gelegt hat*, p. 104.

Edm. Goodwyn, *Connexion of Life with Respiration*. Lond. 1788. 8vo.

J. Hunter, *On the Blood*, p. 68.

J. A. Albers, *Beyträgen zur Anat. und Physiol. der Thiere*, P. 1. p. 108."

[z] Dr. Prout, l. c. p. 526.

But Dr. Edwards has since shown that, however correct were these results, it was erroneous to generalise from them; that more *oxygen* is continually consumed by brutes than goes to the formation of carbonic acid; and that this excess varies from above $\frac{1}{3}$ of the volume of the latter to almost nothing.[a] The variation depends not only upon the species, but upon the developement relative to the age, and upon individual differences in adults.

He therefore finds that the bulk of the air is not unaffected by respiration, but that generally a diminution takes place. Dr. Le Gallois[b] and Dr. Delaroche[c] also found that oxygen disappeared in greater quantity than carbonic acid was formed.

Allen and Pepys observed that, if the same air was breathed repeatedly, some oxygen was absorbed and some azote discharged, and that, if nearly pure oxygen was employed in the case of guinea-pigs, carbonic acid was produced and a portion of the oxygen replaced by azote, this portion decreasing, however, as the experiment proceeded.

Dr. Edwards ascertained that respiration causes sometimes an increase of *azote*, sometimes a diminution, and sometimes no important difference in its quantity. He thinks that it is always being absorbed and discharged, and that the proportion of these processes differs under different circumstances. Its discharge exceeds at all times in very young animals, as seen in guinea-pigs; and in spring and summer; while its absorption exceeds in autumn and winter, as far as his experiments upon adult sparrows and yellow-hammers go; though occasional exceptions occurred from unappreciated circumstances, powerful enough to overbalance the effect of season.[d] The difference in the proportion of the inspired and expired azote never equalled the greatest differences observed between the oxygen which disappeared and the carbonic acid formed. Cold-blooded quadrupeds were shown by Spallanzani[e] to absorb azote, and fish by Humboldt and Provençal.[f] Sir Humphry Davy had already ascertained the absorption of azote in his own person.

Dr. Edwards's reasons for believing azote to be constantly both absorbed and discharged are:—

[a] *De l'Influence des Agens Physiques sur la Vie.* Paris, 1824. p. 410. sqq.

[b] *Annales de Chimie et Physique*, t. iv. p. 115. sq.

[c] *Journal de Physique*, t. 77.

[d] l. c. p. 420. sqq. 461. sqq.

[e] *Mémoires sur la Respiration*, pp. 184. 258.

[f] *Mémoires d'Arcueil*, t. ii.

1. That if an animal is made to breathe oxygen mixed with $\frac{1}{20}$ of azote, azote is discharged in abundance, as was found by Allen and Pepys, so that, when there is little or no azote to be absorbed, its exhalation at once shows itself; and we may conclude that in common respiration its exhalation may be as great, but not observable, because nearly an equal quantity is absorbed:

2. When a mixture of oxygen and hydrogen was employed by those chemists, and pure hydrogen by Dr. Edwards, not only was a large quantity (much exceeding the bulk of the animal) given out, but a considerable quantity of *hydrogen* was absorbed, in Dr. Edwards's experiment equal to the azote given out[g], proving that exhalation and absorption can proceed together: and he asks why, if hydrogen is absorbed, not much more so azote, which is more fit for respiration and the support of life? and concludes that its absorption may be as great in common respiration, but not observable because a nearly equal quantity is discharged.[h]

Carbonic acid itself is shown by Spallanzani and Dr. Edwards[i] to be exhaled from the lungs independently of the operation of oxygen; when snails, frogs, fish, or very young kittens, are immersed in hydrogen.

It is satisfactory that Messrs. Allen and Pepys were induced, without any knowledge of Dr. Edwards's researches, to repeat their enquiries, and their results no longer disagree with those of Dr. Edwards. On making birds breathe in atmospheric air, they still found the loss of oxygen equal to the addition of carbonic acid, and the nitrogen unchanged; if in air with an excess of oxygen, a quantity was absorbed beyond what was replaced by carbonic acid, and in its room appeared an equal quantity of nitrogen; if in a mixture of oxygen, hydrogen, and nitrogen, the oxygen being in the same proportion as in atmospheric air, there was no loss of oxygen, but of hydrogen, which was exactly replaced by nitrogen.[k]

Mr. Ellis[l] contends that the carbon is excreted by the pulmonary vessels, and unites with the oxygen externally, and Dr. Prout thought this opinion corroborated by the fact[m], —that, when phosphorus dissolved in oil is injected into the blood-vessels,

[g] l. c. p. 462.

[h] l. c. 429. sqq.

[i] l. c. p. 437. sqq.

[k] *Phil. Trans.* 1829.

[l] *An Enquiry into the Changes induced in Atmospheric Air.* 1807. *Further Enquiries, &c.* 1816

[m] Dr. Orfila, *Toxicologie Générale,* t. i. p. 531. sq. Dr. Magendie had previously found the same result in injecting the solution into the pleura.—*Mémoire sur la Transpiration,* p. 19.

vapours of phosphorous acid stream from the mouth and nostrils, — what would hardly have occurred if the acid had been formed in the vessels, as it would probably have remained in solution in the blood, not being volatile. The phosphorus was probably excreted from the vessels in minute subdivision, and united with the oxygen of the atmosphere upon coming in contact with it, producing phosphorous acid; and the same may be imagined respecting the carbonic.[n] There can be no reason to adopt this hypothesis on account of the supposed difficulty of the air and blood acting upon each other through the vessels, because we saw in p. 149. that they do so, through moistened bladder, out of the body.

The well-known secretion and absorption of air in membranes, shown by the existence of air in the air-bladder of fish, the sudden formation of air in the alimentary canal in disease, the absorption of air in emphysema, and the occurrence of emphysema without injury of the lungs[o]; the separation of azote and carbonic acid from the lungs when hydrogen is breathed, and the absorption of azote and of oxygen, in the experiments of Dr. Edwards, prove the possibility of the oxygen being absorbed, and the carbonic acid secreted.

Lavoisier at one time, and La Grange and Hassenfratz long ago, contended that the carbonic acid is generated in the circulation, and given off in the lungs, and the oxygen absorbed.

Dr. Edwards also argues that, since so much carbonic acid is given out from the blood in the respiration of pure hydrogen, and that, since the quantity given out in hydrogen is as great as is observed in common air, there can be no reason to doubt that, in common air, the carbonic acid proceeds from the same source as in hydrogen, *viz.* — passes from the blood; more especially as carbonic acid exists largely in the blood: and that the oxygen, therefore, must pass into the blood. These arguments are, in my mind, irresistible. But whether mere carbon leaves the blood and forms carbonic acid with the oxygen externally to the vessels, as in the former theory, or the oxygen unites with, and the carbonic acid separates from, the blood, as in the latter, much of the affair would appear chemical, — neither all the carbon nor all the carbonic acid gas to be *secreted;* because it has long been known,

[n] Dr. Thomson's *Annals of Philosophy.* 1819.

[o] See a case related by Dr. Baillie, in the *Transactions of a Society for the Improvement of Medical and Chemical Knowledge,* vol. i.

that, when venous blood is exposed to oxygen out of the body, even although covered by a moistened membrane, it becomes florid, and oxygen disappears and is replaced by carbonic acid.

Since the publication of Dr. Edwards's work, numerous facts have been ascertained, which cause his opinions on these points to be generally received, by proving the possibility of the transfer of oxygen to the blood, and of carbonic acid to the air, even on chemical principles. My friend Dr. Stevens discovered that oxygen and carbonic acid attract each other; so that, if carbonic acid is placed at the lower part of a tube, and oxygen above, the acid, though heavier, will ascend and the oxygen descend. Nay, if a vessel filled with carbonic acid be completely closed with bladder, the acid will escape and the bladder be forced in; while, if it be filled with air and placed in carbonic acid, the latter will pass through and distend the bladder till it nearly bursts. The tendency to diffusion is universally as the square root of the specific gravity. The subject has been prosecuted by Drs. Mitchel and Faust[p]; and they have ascertained that both living and dead membranes, and even caoutchouc,

[p] *American Journ. of the Medical Sciences*, No. xiii. 1830. They do not mention Dr. Stevens's name, but he had made his observations in the West Indies in 1827 and committed them to paper, and shewn them in England in 1828, in France in 1829, and in America in the summer of 1830, when he mentioned them to the very editor of the *Journal of Medical Sciences*, who took part in Dr. Mitchel's experiments, which were soon afterwards begun and published before the end of the year. In 1833, also, M. Saigay published (in the *Annales des Sc. d'Observat.* t. iii. p.452.) an explanation of the interchange of gases through fluids and porous substances; that each gas maintains an equilibrium outside and inside; so that, when there is less without, it passes forth; and, when more without, it passes in. In this way M. Raspail conceives that the appearance and disappearance of all the various gases in respiration, under different circumstances, may be accounted for. (l. c. p. 258.) There must be, however, a relation between different gases, or nitrogen would be exchanged, as well as oxygen, for carbonic acid, in ordinary respiration.

M. Dutrochet stated that, if a dense fluid is enclosed in an animal membrane, it attracts a thin fluid placed around the exterior. The passage of the external fluid he called endosmose. If the dense fluid is placed externally, and the thin inside, then the thin fluid passes outwards. This passage he termed exosmose. M. Raspail soon adduced exceptions to this, and showed that the phenomena were merely those of ordinary imbibition: that, if the fluid on one side was of a kind to pass through membrane, and the fluid on the other was not, and the two were of a kind to unite, then the one fluid of course soaked into the membrane and, having soaked into it, united with the other fluid, as soon as the other side of the membrane was reached; and more followed in its place. (l. c .p. 80* sqq.)

as well as water and other liquids, are freely permeable to the different gases. They have also discovered that gases pass through with different rapidity: carbonic acid, for instance, very quickly; nitrogen, very slowly: whence the different state of the bladder just mentioned, accordingly as carbonic acid is introduced into the vessel in common air, or common air introduced into the vessel in carbonic acid. The appearance of carbonic acid outside a bladder tied over a vessel of venous blood or water impregnated with carbonic acid, and the disappearance at the same time of a portion of the oxygen outside the bladder tied over venous blood, is no less than what occurs to the blood of the lungs in respiration, and the blood in both cases becomes florid.

The lungs thus seem to serve the purpose, in this respect, of merely exposing an immense surface of blood to the air. Blood could not be so near the air on the exterior of the body without constant injury of the innumerable delicate vessels, nor could the vascular surface be preserved in a moist state, which is necessary to the permeability of those vessels. Besides which, succession of air to each point could not be secured. The Creator has therefore wonderfully provided an immense surface within, of the very finest texture, secure from external injury and supplied with constant moisture, and continually exposed not only to the external air, but to successive draughts of it.

The changes of the blood in respiration are therefore purely chemical, and just the same as occur to venous blood out of the body, in contact with air or separated from it by merely a moistened bladder, and are detailed at page 149. Oxygen unites with the blood; carbonic acid proportionately escapes. The blood, thus liberated from the cause of its blackness, re-acquires the florid hue occasioned by its salts, but which are not naturally in sufficient quantity to brighten it when much carbonic acid is present.

Dr. Crawford observed that less carbonic acid was evolved in proportion to the height of the temperature [q]; Dr. Jurine, that more was evolved when the circulation was quickened, — during the hot stage of fever, digestion, or exercise, and less in the cold stage [r]; and his results were confirmed by Lavoisier and

[q] *On Animal Heat*, p. 387.

[r] *Encyclopédie Méthodique*, t. i. p. 494. Dr. Prout also observed this effect of exercise before fatigue occurred.

Seguin.[s] Dr. Edwards has found less evolved in summer than in winter.[t]

Dr. Prout and Dr. Fyfe[u] have found the quantity of carbonic acid gas diminished by mercury, nitric acid, vegetable diet, tea, substances containing alcohol, depressing passions, long fasting, and fatigue, and probably by sleep. Dr. Prout found that it undergoes in himself an increase from daybreak till noon, and a decrease from noon till sunset, remaining at the minimum till daybreak. In the experiments of Allen and Pepys, the formation of carbonic acid gas slackened when the guinea-pigs fell asleep. Dr. Prout also observed that an increase or decrease from the maximum or minimum was followed by a proportional decrease or increase during a diurnal period. It would appear, also, that less is formed in infancy, and more as the adult age is approached, in brutes.[v]

When the air is not changed, death in general occurs long before all the oxygen is consumed, through the carbonic acid which is formed; but bees, some worms and mollusca, completely deoxidize it.[x] Snails will live in air in which a bird has died.

Lavoisier removed the carbonic acid by potash as quickly as it was produced, and found that a guinea-pig could live in air containing but 6·66 per cent. of oxygen, and with still less became only drowsy.[y]

[s] *Mémoires de l'Académie des Sciences.* 1789. p. 575.

[t] l. c. p. 200. sqq.

[u] l. c. *Dissert. Inaugur. &c.* Edin. 1814. The smallest quantity yet observed was in a diabetic patient of mine, taking very large doses of opium and nux vomica. *Numerous Cases, illustrative of the Efficacy of the Hydrocyanic or Prussic Acid in Affections of the Stomach, with a Report upon its Powers in Pectoral and other Diseases, in which it has been already recommended, and some Facts respecting the Necessity of varying the Doses of Medicines according to circumstances, and the Use of Opium in Diabetes.* By John Elliotson, M.D. &c. p. 99.

[v] Boyle, *Works*, vol. iii. p. 360. Edwards, l. c. p. 189. sqq.

[x] Vauquelin, *Annales de Chimie*, tom. xii. p. 278. Spallanzani, *Mém. sur la Respiration*, p. 63.

[y] Some assert that the respiration of pure oxygen excites violently, others gently, others not at all; some, that more oxygen is consumed than in common, some no more. Mr. Broughton, in a paper read a few years ago in the Royal Society, but not published, found, as Allen and Pepys had previously, that oxygen, when respired pure, excites and causes all the visible blood to be florid; but the animal gradually becomes exhausted, falls in temperature, and at length dies, while the oxygen is still pure enough to produce the same effects on a second and third animal. The blood quickly coagulates after the respiration of pure oxygen. Pure

Dr. Edwards advances, contrary to Morozzo[z], that every warm-blooded animal perishes instantly[a] when placed in the air in which another has died through want of renovation, and that all of the same class among them deoxidize it equally, though in different times. This time will occasionally differ $\frac{1}{3}$, notwithstanding the size of the body and the movements of the chest be equal in them, and the carbonic acid removed as quickly as formed. The young deoxidize it more slowly than adults; and the young, if quite deprived of air, die later than adults.[b] Indeed, Buffon found, and Dr. Le Gallois and Dr. Edwards have confirmed his discovery, that new-born animals of many species, as dogs and rabbits, will live a long time without air, even after they have been allowed to respire. This period lessens as the animal's temperature rises with age; and in those whose temperature is at birth high, as guinea-pigs, it is very short.[c] They live longer than adults also in a limited quantity of air.[d] Amphibious animals likewise live long without air.[e]

Persons have been said to be able, by habit, to live without air a considerable time. Death generally occurs at the latest in one or two minutes, when respiration is suspended; but by habit some few divers of the swimming school at Paris can remain under water three minutes.[f] If the system is in an extraordinary nerv-

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hydrogen and azote appear to destroy by the mere exclusion of oxygen; carbonic acid by poisoning, but, if not diluted with rather more than double its bulk of common air, it will not pass the glottis. Sulphuretted hydrogen instantly poisons: carbonic oxide is fatal less quickly, and the venous blood accumulates within, and the animals are very hot. Nitrous oxide intoxicates quickly, briefly, and without consequent exhaustion, and appears to be absorbed by the blood (see Sir Humphry Davy's *Researches*, &c.); but it destroys at length, and sooner than pure oxygen, according to Mr. Broughton: the blood is thin, and continues fluid. Drowning destroys life only by the exclusion of air; and, as the glottis closes, little or no water — nothing often but frothy mucus — is found in the air-passages. Yet Professor Meyer asserts, that he has seen the fluid in which the animal was drowned, generally, in the lungs, in his experiments.

[z] *Journal de Physique*, t. xxv. p. 102. sqq. One reason that an animal will live in air in which another has died, is, that it comes fresh and strong into it, and therefore resists the poison better than its enfeebled predecessor.

[a] *Mémoires de l'Académie des Sciences*. 1789. p. 573.

[b] l. c. p. 184. sqq.

[c] Edwards, l. c. p. 191. sqq.

[d] l. c. p. 513. sqq.

[e] Sir Anth. Carlisle, *Phil. Trans.* 1805.

[f] Edwards, l. c. p. 269. Mr. Brydone (*Tour through Sicily and Malta*) fre-

ous state of insensibility, the absence of air, like the absence of food or the administration of strong agents, may be borne for a very long time. Even fainting renders submersion less dangerous.

Venous blood is not calculated for life. When it was injected into the carotids, Bichat found that the brain became affected, as if poisoned, and death gradually ensued; and, when it circulated through the coronary arteries of the heart,—the action of which organ will continue though its left cavities are supplied with venous blood,—the heart's motion ceased, and the functions of each organ were impeded, and at length ceased, when venous blood circulated through its arteries.[g] When death occurs by impediment to the functions of the lungs, the heart loses its irritability by its substance becoming penetrated with venous blood, and ceases to propel the blood of its cavities; and the brain, becoming powerless from the same cause, ceases both to perceive uneasiness in the lungs from the want of fresh air, and to be able to will inspiration. If the death of the body arise

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quently saw divers remain, in the Bay of Naples, under water for three minutes. In Percival's *History of Ceylon,* they are said sometimes to remain five minutes under water.

Some very grand instances of exaggeration on this subject will be found in an amusing and useful book, entitled *The Uncertainty of the Signs of Death.* M. D'Egly, Member of the Royal Society of Inscriptions, declares that he was engaged to a dinner for which the fish was to be provided by a Swiss diver, who got his living by plunging into the water and pulling the fish out of their holes. The dinner hour arrived, but no fish. Drags were employed, and the diver's body found. The curate wished to bury it immediately, as it had been nine hours under water, but M. D'Egly determined on attempting resuscitation, and succeeded in three quarters of an hour. The Rev. Mr. Derham, in his *Physico-Theology,* is more credulous than the Curé; he quotes Pechlin for the case of a man pensioned by the queen for having joined his fellow-creatures again, after remaining upright under water, his feet sticking in the muddy bottom, for sixteen hours, at Tronningholm. Yet this is nothing; for Mr. Tilesius, the keeper of the royal library, has written an account of a woman whom he saw alive and well, after being three days under water. And this is nothing; for Mr. Burmann declares he heard a funeral sermon at Boness in Lithovia, upon an old man of seventy, who, the preacher protested, had fallen into the water when sixteen years old, and remained under it for seven weeks. Mr. Brydone was told that one diver, called Calas, but nicknamed Pesce, could live several days in the sea; and Kircher asserts, that this aquatic person could walk under water from Sicily to Italy.

[g] Bichat, *Recherches Physiologiques,* p. ii. art. 6, 7, 8.

from the brain, it is by the brain being unable to continue respiration.

Still the circulation of venous blood excites in some degree for a time, and is better than no circulation; for Dr. Edwards placed some frogs, toads, and salamanders with their hearts entire, and others deprived of their hearts, in water deprived of air. Those with hearts survived the longest, occasionally twenty hours longer than the others.[h] It is worth remembering, as Dr. Stevens has pointed out, that blood may be black from the presence of carbonic acid, &c. or from the absence of saline matter.

Venous blood both abounds in carbonic acid and is deficient in oxygen. The state of combination of the oxygen abounding in arterial blood, and of the carbonic acid abounding in the venous, are unknown. As the blood is florid until it reaches the minutest vessels, we presume that in them the oxygen disappears, and the carbonic acid is produced. The oxygen is thought to meet with carbon there, and with it form the carbonic acid. Dr. Prout conceives that the carbon is derived from the albumen, when albuminous matters are converted into gelatine. This substance, which is not found in the blood nor in any glandular secretion, enters into the structure of every part, and especially of the skin, which is little else. Now this contains three or four per cent. less carbon than albumen. In nutrition, therefore, albuminous substances very extensively support a reducing process, lose their carbon to become gelatinous, and as this process must occur in the minutest vessels, their blood is charged with carbon, which, however, instantly finds oxygen (probably in solution in the water of the blood), and unites with it into carbonic acid.[i] It is thus that respiration assists assimilation, and not by discharging carbon from the chyle, as many have imagined. They forget that more carbonic acid is not found after every meal, nor less during fasting, till this proceeds to the length of debility: and that many animals sleep after feeding, yet in sleep less is produced.

Some suppose that respiration is very instrumental in preventing the putrefaction of the living body; and this by carrying off its carbon, — the substance which, in the spontaneous decomposition of animals, is the first rejected, and unites with the oxygen of the atmosphere; and, indeed, Spallanzani found, that the dead

[h] l. c. P. 1. c. i. sect. 2.

[i] *Bridgewater Treatise*, pp. 519. 524. sq. 535. sq.

bodies of animals deoxidated the air after death, and often as much as during life, before decomposition was perceptible.[k] He says also, that torpid animals, whose respiration had entirely ceased, also carbonated it. As the latter fact cannot be ascribed to the separation of carbon in the lungs, nor to the mere chemical changes of decomposition, it probably arises from the functions of the skin.

The delicate surface of the lungs, and, indeed, of the whole air-passages, is a great source of absorption from without, as well as of impressions from gaseous and imponderable substances. Many poisons affect the system by its means. It is also a great organ of elimination. Camphor, phosphorus, ether, diluted alcohol, gases, and various odorous substances, when introduced into the system, escape in a great measure by the lungs: whence they are perceived in the breath, and, perhaps for some time, long after they have left the stomach. Dr. G. Breschet and Dr. Milne Edwards, conceiving that in the dilatation of the lungs by inspiration, the enlarged space would cause not only the air to rush in, but the exhalation from the surface of the air-cells and pleura to increase and exceed that from other parts, have made several experiments which prove this to be the case. On injecting a *small* quantity of oil of turpentine into the crural vein, the breath instantly smelt strongly of it, and the pleura on being cut open did the same; while no odour of it arose on exposing the peritonæum. If a larger quantity was employed, it impregnated every part. If, instead of natural respiration, artificial was instituted, in which the air does not enter the lungs by the formation of a vacuum on the expansion of the chest, but is forced into them and itself expands the chest, no more exhalation of odorous substances took place from the lungs than from other parts; and, indeed, if a cupping-glass was applied over another denuded part, the odorous substance was given out there, while the lungs afforded no sign of it.[l]

" The perpetual change of elements occurring in respiration after birth, we shall show to be very differently accomplished in the fœtus, viz. by means of the connection of the gravid uterus with the placenta.

" But, when the child is born and capable of volition, the congestion of blood that takes place in the aorta, from the obstruction in the umbilical arteries; the danger of suffocation from

[k] *Mém. sur la Respiration.* See Dr. Bostock, l. c. vol. ii. p. 184. sqq.

[l] *Recherches Expérimentales sur l'Exhalation Pulmonaire.* Paris, 1826.

the cessation of those changes of the blood, in regard to oxygen and carbon, hitherto produced in the uterine placenta; the novel impression of that element into which the child, hitherto an aquatic being, is conveyed; the cooler temperature to which it is now exposed; and the many new stimuli which are now applied, seem to induce new motions in the body, especially the dilatation of the chest and the first inspiration.

"The lungs, being for the first time dilated by inspiration, open a new channel to the blood, so that, being obstructed in the umbilical arteries, it is derived to the chest.

"Since the inspired air becomes hurtful and unpleasant to the lungs by the decomposition which it experiences, I should ascribe to the most simple corrective powers of nature, the subsequent motion by which the poisonous mephitis, as it may be called, is expelled and exchanged for a fresh supply.

"The consideration of all these circumstances, especially if the importance of respiration to circulation, demonstrated by the well-known experiment of Hooke [m], be remembered, will, in my opinion, explain the celebrated *problem* of Harvey [n], better [o] than most other attempts of physiologists.[p]

[m] "It has the epithet Hookian, because it was most varied by Rob. Hooke. See Th. Sprat, *History of the Royal Society*. Lond. 1667. 4to. p. 232. But it was before instituted by Vesalius, and very much praised for its beauty. *De c. h. Fabrica*, p. 284."

The experiment consisted in laying the lungs completely bare, and reviving the animal by artificial respiration. Hooke varied it by pricking the surface of the lungs, and forcing a continued stream of air through them.

[n] "Wm. Harvey, *De circulat. sanguin. ad* J. Riolan. p. 258. Glasgov. 1751. 12mo."

These are the words of Harvey: — "It would appear that the use of expiration is to purify and ventilate the blood, by separating from it these noxious and fuliginous vapours." We must not, however, forget the words of Servetus, seventy years before, and already quoted at p. 195. — *expiratione fuligine expurgatur*.

"And especially his *Exerc. de gener. Animalium*. p. 263. Lond. 1651. 4to."

[o] "See Theod. C. Aug. Roose, *über das Ersticken neugeborner Kinder*, in his *Physiologisch. Untersuchungen*. Brunsw. 1796. 8vo.

J. D. Herholdt, *De vita, imprimis fœtus humani, ejusque morte sub partu*. Havn. 1802. 8vo."

[p] "Consult, for example, Petr. J. Daoustenc, *De Respiratione*. Lugd. 1743. 4to. p. 54. sqq.

Rob. Whytt, *On the Vital and other Involuntary Motions of Animals*, p. 222. Edinb. 1751. 8vo."

Fish and *crustacea* purify their blood by the air contained in the water which they draw over their gills. They perish if the water is deprived of air; and in this case, as well as when the water is aërated but limited in quantity, and whether it is exposed to the air or in close vessels, they perish sooner as the temperature is higher. (Dr. Edwards, l. c. P. ii. ch. 2.) And the younger and smaller they are, when there is too little air in the water, the more they come to breathe at the surface, and the sooner die if prevented. (p. 118.) Fish die in the air by drying and wasting. (p. 126.) The *syren lacertina* and *proteus anguina* have both gills and lungs. *Insects* have no lungs, but openings on the surface of the body leading to air-vessels which are distributed in the interior. Dr. M. Hall has shown that, in the lungs of at least the toad, frog, and salamander, the blood-vessels subdivide into capillaries suddenly, so as to subdivide as much blood as possible, and cause it to present the largest possible surface. (l. c. p. 36. sqq.) All the experiments of naturalists made it appear that no animal could live without oxygen, but M. Biot has asserted that what are called *blaps* and *tenebrions* remain in as good a vacuum as can be formed for any length of time without apparent inconvenience. Animals found in many parts of the bodies of others can hardly be thought to have access to gaseous oxygen. In regard to the frequency of respiration in cold-blooded animals, Dr. Stevens incidentally mentions that he observed it no more than three or four times in a minute in an alligator, which he once held in his hand, and in which it was probably quick from the animal being young and agitated. (l. c. p. 35.)

In the light, vegetables produce changes in the air opposite to those produced by animals. They decompose carbonic acid, retain the carbon, and leave the oxygen. It is the green substance of *the living* leaf which effects the decomposition. In the dark, the leaves absorb oxygen; a tendency which, indeed, the flowers, roots, and other parts, always have. This oxygen unites with the carbon of the sap; and, although some of the carbonic acid formed is said to be exhaled, the greater portion combines with the fluids of the sap, and parts with its oxygen again in the leaves when daylight comes. Carbon obtained in the state in which it exists at the moment of its separation from carbonic acid appears the object. While animals, therefore, increase the carbonic acid of the atmosphere and lessen its oxygen, vegetables increase its oxygen and lessen its carbonic acid, at least during the light; and the functions of vegetables are the most active at that period of the year when the days are much longer than the nights.

CHAP. XIII.

ANIMAL HEAT.

"MAN, other mammalia, and birds, are distinguished from the rest of animals by the natural temperature [a] of their bodies greatly exceeding that of the medium in which they are accustomed to exist. Man is again distinguished from these classes of animals by possessing a much lower temperature than they; so that in this climate it is about 96° of Fahr., while in them, and especially in birds, it is considerably higher." [b]

But all animals, as far as can be ascertained, and even vegetables, have a tendency to preserve a temperature more or less distinct from that of the surrounding medium; yet the difference among them in this respect is so great, that they have been divided into warm and cold-blooded. To the former belong the more complicated, those whose pulmonary apparatus is most elaborate, — man and mammiferous quadrupeds and birds: to the second, oviparous quadrupeds, fish, and most of the invertebrate. Birds have the highest temperature, 107° to 110°; mammiferous quadrupeds, 100° to 101°; man, 96° to $98\frac{1}{2}$°. There is some variety, not only in individuals, but according to age, season, and climate. It is less in the young, according to Dr. Edwards and Despretz [c]: the former states the human temperature in infancy to be $94\frac{1}{4}$°; the latter asserts, that, while in birds it is 105° in winter, it is nearly 111° in summer, gradually increasing in spring and decreasing in autumn. In the high temperature to which we

[a] "W. B. Johnson, *History of Animal Chemistry*, vol. iii. p. 79."

[b] "The torpid state of some animals, during winter, is of course an exception to this. During it most of the functions cease or languish considerably, and the animal heat is reduced nearly to coolness. This well-known circumstance prevents me from acceding to the opinion of the very acute J. Hunter, — that the animals which we call warm-blooded should rather be called animals of a permanent heat under all temperatures. *On the Blood*, p. 15."

[c] *De l'Influence des Agens Physiques. Edinburgh Journal of Science*, vol. iv. p. 185. J. Hunter states that the temperature of the ass is one degree higher in the evening than the morning. - *On the Blood*, p. 298.

shall see Dr. Fordyce and his friends were exposed, the temperature of the body rose two or three degrees, and Dr. Delaroche, in a vapour-bath at near 120°, found the heat under his tongue increased about five degrees at the end of seventeen minutes.[d] In sparrows and yellow-hammers, Dr. Edwards found it five or six degrees higher in summer than in winter; and Dr. Davy one or two degrees higher in Ceylon than in England.[e] In disease it will fall, and on the other hand rise; in fever it has been noted at 107°, in tetanus at 110°[f], and probably, on some occasions, it rises still higher, at least locally. I have myself found it 107° under the tongue, in even acute rheumatism, and seen inflamed parts show this temperature, when the bulb of the thermometer was placed upon them and covered up. When a function is going on vigorously, the temperature of the individual part rises: as we observe in the genitals during sexual excitement. Certain parts of some animals are naturally of a lower temperature than the rest, v. c. the dog's nose. Disease will have the same effect. In affections of the stomach, its temperature will fall: so that the patient will not only complain of its coldness, but discharge fluid from it into the mouth that strikes cold immediately. In cancer of the bladder, I once saw a man complain greatly of the constant coldness of his glans penis. In old age it is not so high as in the age of full vigour; nor in remote parts as in those nearer the heart.[g] John Hunter made observations on the heat of cold-blooded animals.[h] The thermometer in the stomach and under the skin of the abdomen of the frog and toad stood at 40°, when the atmosphere was 36°; in the lungs of snails at 35°, 36°, 37°, 38°, when the atmosphere was 28°, 30°, 30°, and 34°; the heat of earth-worms was $58\frac{1}{2}$°, when the atmosphere was 56°. Fish are not above two degrees warmer than the water.[i] Cold-blooded animals placed in an elevated temperature are much more influenced by surrounding media than the warm-blooded. Yet frogs are but at 80° or 82° in a medium of 110° or 115°.[k] The heat of insects when congregated is considerable: J. Hunter found the thermometer rise to 93° or 98° in a hive of bees in

[d] *Exp. sur les effets qu'une forte chaleur produit sur l'économie.* Paris, 1805.

[e] Edwards, l. c. p. 489.

[f] Dr. Prevost. See Dr. Edwards, l. c. p. 490.

[g] Dr. Davy, *Phil. Transact.*, 1814.

[h] l. c. 298. sqq.

[i] *Edinburgh Journal of Science*, vol. iv.

[k] Dr. De la Roche, *Journal de la Physique*, t. lxiii.

spring; to 104° in summer; to be at 82° when the air was at 40°; and at 73° in winter.

The same tendency in vegetables is shown by the greater difficulty with which the juices in their stems and branches are frozen than lifeless fluids; by ice thawing when roots shoot into it [l]; and by snow upon the leaves or stems of plants thawing sooner than that which lies on surrounding inanimate bodies. J. Hunter observed a branch of growing fir and a bean leaf thaw the part of the surface of a freezing mixture on which it was placed, and the fir subsequently another to which it was removed. [m] When the sheath of the arum maculatum and cordifolium is bursting, and the cylindrical body just peeping forth, it is said, by Sennebier, to be so hot for some hours as to seem burning [n]; and twelve of them placed round the bulb of a thermometer to have raised the mercury from 79° to 143°.

Even eggs are cooled and frozen with more difficulty than equal masses of inanimate matter; although, when once frozen and their life destroyed, they freeze readily. [o]

"This natural temperature in man is so constant, equable [p], and perpetual, that, excepting slight differences from variety of constitution, it varies but a few degrees in the coldest climate and under the torrid zone. For the opinion of Boerhaave, — that man cannot live in a temperature exceeding his own, has been refuted, since the admirable observations [q] of H. Ellis, the celebrated traveller, and formerly the governor of Georgia, by the remarkable experiments [r] of many excellent physiologists." [s] Dr. Fordyce,

[l] *American Medical and Philosophical Register*, vol. iii. p. 19. 1814.

[m] *Phil. Trans.*, 1775.

[n] *An Introduction to Physiological and Systematic Botany.* By Sir J. E. Smith, M.D. p. 92.

[o] J. Hunter, l. c. p. 79.

[p] "J. B. Van Mons, *Journal de Physique*, t. lxviii. 1809, p. 121."

[q] "*Philos. Trans.* vol. i. p. ii. 1758.

Arn. Duntze had previously made the observation in regard to brutes. *Exper. calorem animalem spectantia.* Lugd. Bat. 1754, 4to.

Consult also Benj. Franklin, *Experiments and Observations on Electricity.* Lond. 1769, 4to. p. 365."

[r] "Duhamel and Tillet, *Mém. de l'Acad. des Scienc. de Paris*, 1704.

Blagden and Dobson, *Philos. Trans.* 1775."

[s] "The heat of the weather, even in Europe, occasionally exceeds our natural temperature. This was the case on the 3d of August, 1783, at noon, when I was on the Lucerne Alps, in company with the excellent Schnyder of Wartensee.

one of the most eminent of my predecessors at St. Thomas's Hospital, went successively into rooms heated to 90°, 110°, and 120°. In the first temperature he staid five minutes, and sweated gently. In the second, he sweated more profusely, and remained ten minutes. In the third, after remaining twenty minutes, the thermometer under the tongue and exposed to the urine was at 100°, the pulse was 145; the veins of the surface were enlarged, and the skin red. He afterwards entered a room heated to 130°, and staid 15 minutes: the thermometer under the tongue, in the hand, and exposed to the urine, was at 100°.

Sir Joseph Banks, Sir Charles Blagden, and Dr. Solander, went subsequently into rooms heated to between 196° and 211°,—about the temperature of boiling water,—and remained several minutes. If they breathed on the thermometer, it sunk several degrees, and every expiration felt cold to the scorched nostrils: the thermometer under the tongue was 98°, and the body felt cold to the touch, though at 98°. Sir C. Blagden remained eight minutes in an apartment heated to 260°. The air felt hot, and for seven minutes the breathing was natural, but anxiety and oppression then came on; the sensible heat of the body varied but little. Dr. Dobson went into a room heated to 224°, and felt no oppressive heat, though every metal about him speedily became hot. A bitch of moderate size was subjected to a heat of 220°. In ten minutes the only sign of distress was that of holding out the tongue, and when taken out at the end of half an hour, the temperature being at 236°, the bottom of the basket was found wetted with saliva. The thermometer applied to her flank was only 110°, *i. e.* 9° above the natural standard.

In these rooms, eggs on a tin plate were roasted hard in twenty minutes; beef-steaks cooked in thirty-three minutes; and, if the air was impelled upon them in a stream, they were cooked dry in about thirteen minutes.

Tillet and Duhamel relate that the young female servant of a baker at Rochefoucault went habitually into ovens heated to 276°, and remained without great inconvenience for twelve minutes, taking care not to touch the oven. These gentlemen themselves bore a heat of 290° for nearly five minutes. Dr. Delaroche and

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The thermometer in the shade stood above 100° Fahr., and, when applied to the body, invariably sunk to near 97°."

Dr. Berger found various warm and cold-blooded animals support from 108° to 113° for an hour and a half in heated dry air; but an elevation of about 30° beyond this killed them all, except a frog, in from half an hour to two hours. They themselves experienced a sense of scalding in a *vapour*-bath of 122°, and could not bear it more than about ten minutes; while M. Lemonnier could not bear a *water*-bath of 113° above eight minutes.[t] Hence, at the very same high temperature of the surrounding medium, there is more secretion by the skin in a vapour-bath than in dry air, and more in a water-bath than in a vapour-bath.

"The striking prerogative of man, in respect of bearing a variety of temperatures, is evinced by his being restricted to no climate, but inhabiting every part of the earth, from Hudson's Bay, where mercury freezes, and from Nova Zembla, to the scorching shores of Senegal."

At Sierra Leone, the mean temperature is 84°, and Watt and Winterbottom frequently saw it 100° and even 103° in the shade. At Senegal, it has been 108½°, and even 117½°. During the sirocco, it is 112° in Sicily; Humboldt saw it 110° and 115° near Oronoco, in South America. On the other hand, at Nova Zembla the cold is so intense that, when the sun sinks below the horizon, the polar bear is no longer seen, the white fox only enduring the cold. Yet the Dutch, who wintered there under Hemskerk (76° N. L.), withstood the cold, if moving about and previously in good health. When some of our countrymen were on Churchill River, in Hudson's Bay, lakes ten or twelve feet deep were frozen to the bottom, and brandy froze in their rooms, though provided with fires. They suspended in their rooms red-hot twenty-four pounders, and kept an immense fire: but, if these went down, the walls and beds were covered with ice three inches thick.[u] Yet in Hudson's Bay the Canadians and Esquimaux live and hunt in the coldest weather. Gmelin, sen. witnessed at Jeniseisk, in 1735, a cold of —20°, that froze mercury and killed all the sparrows and jays.[x] Captain Parry once observed a temperature of 52° below zero. When the air was at —49°, the party used to walk on the shore. It was usually at —32°. The temperature of eleven out of sixteen foxes was from 100° to 106¾°, of four about 100°, and of one only 98°, although the

[t] Dr. Edwards, l. c. p. 374., and indeed, see p. 4. ch. xiv.

[u] *Philosophical Transactions*, abridged, vol. iii. p. 470.

[x] *Flora Sibirica.* Preface.

air was from —3° to —32°. No relation was observable between the temperature of the body and of the atmosphere[y]; it thus appearing that the temperature is more steady under cold than heat. I may here remark that, if an animal is drowned in hot water, a puppy or kitten, for example, in water at 90° or 120°, the action of its heart irrecoverably ceases sooner than if it is drowned in cold water.[z] Under the want of respiration the heat is too exhausting for the powers of the system. When animals recover, they regain their warmth slowly, even more slowly, Mr. Nunnelly says, than after immersion in cold water. Oxygen also excites so much, that it exhausts and lowers the temperature.

Another wonderful circumstance is the impunity with which great *changes* of temperature are borne by persons in good health, and under neither mental nor corporeal accidental depression at the moment. The Russian, while in a vapour-bath of perhaps 167°, has several large vessels of cold water poured upon him: and the Finnish peasant passes reeking from it, and rolls in the snow, with exquisite delight. Sir Joseph Banks and the rest of the party passed from the high temperature mentioned into the cold air, and even staid some minutes before they dressed, without the least injury. During an unnaturally high temperature, the sudden application of cold is very agreeable.

No phenomenon in living bodies is more remarkable than their peculiar temperature, and no one was of more difficult explanation before the modern progress of chemistry. Dr. Mayow had indeed advanced, that it depended on respiration, and that this was a process similar to combustion, and, so far from cooling the blood, as others believed, supplied it with heat.

If two different bodies are placed in a temperature higher or lower than their own for a certain length of time, they will, at the end of the period, be found, not of the same, but of different temperatures. That which has the higher temperature is said to have a smaller capacity for caloric; that which has the lower, a greater capacity. To raise the former to a given temperature, therefore, requires less caloric than to raise the latter to the same degree.

[y] *Journal of a Second Voyage*, p. 157.

[z] Experiments by Sir Astley Cooper, in 1790, published from his MS.; by Dr. Hodgkin, in the translation of Dr. Edwards's work, p. 472. sqq. Similar results are there related by Mr. Nunnelly.

The temperature of solids is more easily affected by a given quantity of caloric, than that of fluids, and the temperature of fluids than that of aëriform bodies; or, in other words, solids have a smaller capacity for caloric than fluids; and fluids than aëriform bodies. If, therefore, a solid becomes fluid, or a fluid aëriform, it absorbs a great quantity of caloric, notwithstanding its temperature remain precisely the same. And the converse holds equally good: — if an aëriform substance becomes liquid, or a liquid solid, the caloric which it before contained is now, from its diminished capacity, much more than sufficient for the temperature which before existed, and the temperature of the body accordingly rises.

In respiration, the dark blood of the pulmonary artery parts with a portion of its carbon, and acquires a florid hue. Oxygen disappears, and carbonic acid is expired with the other constituent of the atmosphere — nitrogen or azote, which seems usually to have experienced little or no change from inspiration.

The celebrated Dr. Crawford of St. Thomas's Hospital appeared to prove, by his experiments, that the arterial blood has a larger capacity for caloric than the venous, and common air than carbonic acid gas. He therefore argued thus: — when the carbonic acid appears in the lungs, the smaller capacity of this than of common air for caloric, must cause an increase of temperature; but the blood, having changed from venous to arterial, has acquired a greater capacity than before, and absorbs the heat given out by the carbonic acid. The blood, of course, does not become warmer, because the caloric is not more than sufficient to render its temperature equal to what it was previously; and, indeed, according to some, it is not quite sufficient for this, since the temperature of the florid blood of the pulmonary veins has appeared two degrees lower than that of the pulmonary artery to some experimenters, although the greater number have found it a degree or two higher than the dark blood.

The body in this way acquires a fund of caloric, and yet the lungs, in which it is acquired, do not experience any elevation of temperature; or, if they do, this is very inconsiderable.

The arterial blood, charged with much caloric, which, as it circulates through the small vessels, is not sensible, becomes venous, — acquires a dark hue, and its capacity for caloric is diminished; consequently its temperature rises, — the caloric which was previously latent is, from the decrease of capacity, sufficient to raise its temperature, and is evolved. In this mode,

the loss of caloric which occurs from the inferior temperature of the medium in which we live, is compensated. The fresh supply is taken in at the lungs, and brought into use in the minute vessels.

Dr. Crawford's theory afterwards fell into some discredit.

All experiments upon the capacities of bodies for heat are very delicate and liable to error; and the conclusions of Dr. Crawford on this point have been denied by Drs. Delaroche and Berard, with respect to gases, and by Dr. Davy, with respect to arterial and venous blood.[a]

The experiments of these chemists have led them to believe the difference of capacity less than Crawford supposed, and insufficient to account for animal temperature. With respect to the gases, Dr. Bostock[b] justly remarks, that the objection does not apply more to the doctrine of animal heat, than to the theory of combustion in general. Whenever carbon unites with oxygen, and carbonic acid is produced, caloric is liberated, whether in fermentation, or combustion, &c. With respect to the blood, he declares, and Dr. Bostock's reputation for accuracy and soundness in chemical matters is not little, that, "after attentively perusing the experiments of Crawford, and comparing them with those that have been performed with a contrary result, he confesses that the balance of evidence appears to him to be greatly in favour of the former, though he acknowledges that they are of so delicate a nature as not to be entitled to implicit confidence, and that it would be extremely desirable to have them carefully repeated."

If, however, it were true that Dr. Crawford's statement of the relative capacities is incorrect, still the fact of heat being necessarily evolved on the disappearance of oxygen in the lungs, and the appearance of carbonic acid, provided they unite there, would stand unaffected, and we should only be obliged to adopt the doctrine of Mayow, that the lungs are the focus of the heat of the body. This was relinquished, on the objection that the lungs should then be hotter than other parts. But, when we consider that the blood is incessantly streaming to the lungs from all parts and again leaving them, we may, I think, presume that the blood will always convey away their heat, and prevent their temperature from rising above that of other parts. The heat of all parts is, cæteris paribus, commensurate with the quantity of blood circulating through them, and this is equally explicable on the

[a] *Philos. Trans.* 1814. [b] l. c. vol. ii. p. 263.

supposition that the carbonic acid is formed in the lungs, or in the extreme vessels of all parts. If their heat is derived from the heat of the blood conveyed to them, the more blood streams through them, the hotter will they be ; if from chemical changes in the blood while in them, the more blood streams through the extreme vessels the greater will be the amount of chemical change, and the greater the extrication of caloric. The quantity of blood, unless constantly renewed, is inefficient, on either supposition. On the first, fresh blood must come incessantly from the lungs with its high temperature; on the second, if not renewed, its chemical changes will cease, having already occurred.

As it is now generally believed that the oxygen which enters into the blood combines with the carbon, not in the lungs, but in all the extreme vessels, and in them forms carbonic acid, the evolution of heat throughout the body is thus at once explained, — it is a mere instance of combustion in the extreme vessels, the union of carbon and oxygen being always attended by an increase of temperature[c]; and we may equally abstain from troubling ourselves about relative capacities for caloric. The fact of local heats above the temperature of the general mass of blood, proves that heat is evolved by local processes. If arterial blood is made venous, or, more properly, blackened, by galvanism, heat is evolved, as I shall presently mention. Those who believe that venous blood has a larger capacity for caloric than the arterial, say that the heat evolved in the minute vessels, by the formation of carbonic acid, does not produce so high a temperature as it would, were the capacity of the blood for caloric not lessened by the changed character of the fluid: but, that, when rendered florid again in the lungs, its capacity is again reduced; and, not only is there sufficient caloric to raise the cold air to 98°, but the florid blood becomes one or two degrees higher than it was when venous in the right side of the heart. It is evident that, if the chemical changes which occur in the lungs are independent of life, and even take place out of the body, and the evolution of heat is a purely chemical phenomenon, it also will occur in

[c] If the combustion thus takes place in the universal extreme vessels, the opinion of Tiedemann and Gmelin, that the use of the liver is to liberate the blood of much carbon without its union with oxygen, will not be the less probable than if the union occurred ordinarily in the lungs. If carbon is copiously removed without uniting to oxygen and forming carbonic acid in the blood, we understand why the blood in high temperatures is less dark, is even florid.

the blood out of the body. Accordingly Sir C. Scudamore, exposing two portions of the same blood, under the same circumstances, the one to atmospheric air, the other to oxygen, found the temperature of the portion exposed to oxygen eight degrees higher at the end of eight minutes than that of the other.

It is possible that other chemical changes, which incessantly go on throughout the frame, also occasion heat to be evolved.

A host of circumstances show that our temperature depends upon respiration, and therefore upon chemical changes.

In high temperatures we have less necessity for the evolution of heat; in low temperatures, more. Accordingly, in the former, the arterial blood remains arterial,—is nearly as florid in the veins as in the arteries [d], and the inspired air is less vitiated; in low temperatures, the venous blood is extremely dark, and the inspired air more vitiated. [e] Some have imagined that the body remains at its standard high temperature by the refrigeration of the evaporating sweat. But, though this must contribute, it is not the sole cause [f]; for frogs lose as much proportionally to their size by evaporation as any other animal, yet they follow pretty closely the surrounding temperature. Whenever, on the other hand, the body itself heightens its temperature, as in fever, more oxygen is consumed by the lungs [g]; (in the cold stage of fevers we saw that less was consumed.) The temperature of the various classes of animals, and their vitiation of the air, are always proportional; and inverse to the length of time they can live without air.

[d] Dr. Crawford, l. c. p. 387. sq. Dr. De la Roche, l. c.

[e] Dr. Crawford, ib. " C. Ferd. Becker, *De Effectibus caloris et frigoris externi in c. h.* Gott. 1802. 4to.; and Wm. Fr. Bauer, *On the same subject.* IB EOD. (BOTH HONOURED WITH THE ROYAL PRIZE.)

Mich. Skjelderup, *Dissert. sistens vim frigoris incitantem.* Hafn. 1803. 8vo."

Yet, in the account of Sir Astley Cooper's experiments, quoted at p. 235., it is mentioned that a puppy and a kitten, some weeks old, were placed nearly to the mouth in iced water, till they died; and that the blood of the lips, nose, toes, mesentery, and left side of the heart, was of a fine vermilion hue. The colour of the venous blood is not mentioned. I should presume it was very dark, but that the oxygen, from the great coldness of the air inspired, was so effective in withdrawing the carbonic acid, that the arterial blood was, on this account, unusually florid.

[f] Dr. Edwards, l. c. p. 488.

[g] See supra, p. 222.

The temperature of young animals is lower than of adults, or rather they maintain a peculiar temperature much less, are more easily cooled and heated, and they vitiate the air less, and require respiration less, proportionally, than adults.[h] As they proceed to vitiate it more, and require respiration more, their calorific power increases. While their calorific powers are weak, they breathe, if they are exposed to cold, more quickly, so as to keep up their temperature as much as possible.[i] The same we shall find is true of adult warm-blooded animals, not of the hybernating family, when exposed to cold.

Dr. Edwards found that habit has great influence on the calorific powers of animals; — that a given low artificial temperature in winter will reduce the animal heat much less than in summer[k]: and that, with the habit of evolving more heat in winter, is acquired the habit of consuming and requiring more oxygen, so that animals supplied with a given quantity of air, and placed in a given warm temperature in winter, die much sooner than in summer.[l] Yet the *momentary* application of heat or cold has a different effect: the former heating less if the body has been subjected to a low, and the latter cooling less if the body has been subjected to a high, temperature. We all feel the cold less quickly on leaving the house in winter if well warmed first, than if we leave it already chilly.

When animals hybernate, their temperature falls, and respiration is nearly or entirely suspended.[m] Their consumption of air lessens as the temperature falls, whence they consume less in November than in August.[n] If hybernating animals, while torpid and still placed in the same temperature, are stimulated mechanically to breathe, their temperature rises with the progress of respiration.[o]

If the cold to which they are exposed is so intense that it threatens death, it actually no longer depresses respiration, but, for a time, excites it, and their temperature rises proportion-

[h] Dr. Edwards, l. c. p. 165. sqq.
[i] l. c. pp. 299. 310.
[k] l. c. p. 162. sqq. 252. sqq.
[l] l. c. p. 200. sqq.
[m] Spallanzani, *Mémoires sur la Respiration*, p. 77. De Saissy could not by cold produce torpor in a marmot, till he had deprived it of fresh air. Edwards, l. c. p. 154.
[n] M. de Saissy. See Edwards, l. c. p. 286.
[o] M. de Saissy. See Edwards, l. c. p. 305.

ally.[p] Man and other non-hybernating animals breathe more quickly when exposed to cold (no doubt for the purpose of supplying heat) till the powers become exhausted.[q]

The higher the temperature of the animal, the more extensive is the aggregate surface of the air-cells, the more blood passes through its lungs, and the more necessary to its existence is respiration.— The lungs of cold-blooded animals are not subdivided into minute cells, but formed into vesicles; and birds, which have the highest temperature among animals, are drowned the soonest.[r] Respiration is much slower in the cold-blooded. Dr. Stevens found an alligator breathe but three or four times in a minute, though young, and agitated at being held.[s]

The changes of the air by the blood are seen to be effected entirely by the red particles. Prevost and Dumas found that the number of red particles is proportionate to the temperature.

If the blood circulates without being first properly changed in the lungs, the temperature is below the natural standard. Those who have the blue disease (cœruleans[t]), some of whose blood reaches the left side of the heart without passing through the lungs, are cold: and coldness is a symptom of hydrothorax, and of the repletion of the air-cells with mucus in chronic bronchitis; in the former of which affections the lungs cannot fully expand; and in the latter the air is prevented from coming fully in contact with the air-cells, and mucus Priestley found to be a barrier to the influence of oxygen on the blood. (p. 149.)

In cold climates, and in temperate ones in cold weather, animal food is desired and taken in abundance; in hot climates, and during the summer in temperate regions, light vegetable food is preferred, and the appetite is less. We may conceive the former diet more calculated to support a process similar to combustion, and under the former circumstances we have seen that the changes of the air in the lungs are actually more considerable.

[p] Dr. Edwards, l. c. p. 306. sq. [q] l. c. p. 301.

[r] Boyle's *Works*, vol. iii. p. 368. [s] l. c. p. 35.

[t] "Sometimes the septa of the heart are imperfect, sometimes the aorta arises with the pulmonary artery from the right ventricle, as in the tortoise. In such instances, the chemical changes can take place in the lungs but imperfectly.

Consult a host of cases in J. C. Hein's *Diss. de istis Cordis deformationibus quæ sanguinem venosum cum arterioso miscere permittunt*. Gotting. 1816. 4to."

Mr. Allan Burns, *Essay on Diseases of the Heart*, and Dr. Farre, *Treatise on Malformation of the Heart*, give accounts of these cases. See also Andral.

Warm-blooded animals are continually eating; birds, whose temperature is the highest, incessantly, if they can obtain food; whereas the cold-blooded eat little and seldom. Some make a meal only once in three or more months; Dr. Stevens saw a large rattlesnake, plump, active, and venomous, which was said not to have tasted food for nine months.[u]

The temperature of parts falls if not maintained by a constant stream of blood from the lungs through the aorta and its ramifications, and is, cæteris paribus, in exact proportion to this supply. When parts shrink, and are pale, they are cold from want of blood: when they do not shrink, or they are even full, turgid, and purple, they are cold from the want of *changed* blood. Still for a time respiration may not be quick and yet the temperature high, as in the yellow fever of the West Indies[v]: combustion may go on rapidly in the extreme vessels of a part or the whole of the body, for a limited period, disproportionately to the removal of the product,—the carbonic acid,—in the lungs, and the supply of oxygen for the combustion. On the other hand, general or local temperature may be low though respiration be rapid, for it may carry off carbonic acid and supply oxygen to little purpose, if the circulation in the extreme vessels languishes.

Whether the theory be correct or not, the production of animal heat must be as evidently a chemical process, as changes of temperature among inanimate bodies; yet some ascribe it to nervous energy. I cannot imagine nervous energy to cause heat any more than to cause chemical affinity. As it may bring substances into proximity which have an affinity for each other, and thus produce their union, so it may effect those changes which are, according to physical laws, accompanied by changes of temperature; but caloric in the body must, I apprehend, like affinity, follow the same laws, and no others, as out of the body. This, however, does not prevent animal temperature from deserving the epithet vital, because it is regulated by the vital powers of the system, although through the instrumentality of chemical changes. If the high temperature of an inflamed part is owing to the increased momentum,—the increased sum of the quantity and velocity of its blood,—yet this increased momentum is produced by the vital powers.

Sir B. Brodie removed the brain of animals, and continued

[u] l. c. p. 35. [v] Dr. Stevens, l. c. p. 33.

respiration artificially. The usual chemical changes of the blood continued in the lungs; yet the temperature of the animals diminished, and even more rapidly than if the respiration had not been continued, owing, it is said, to the succession of cool air sent into the lungs. He therefore concludes that animal heat depends much more upon the nervous energy than upon the chemical changes of the blood.[x] But this experiment proves nothing; because Dr. Le Gallois asserts that, under artificial respiration the temperature may fall, and the animal actually be killed by cold, even though every part remain uninjured.[y] In artificial respiration the air does not rush into the pulmonary cells, because these are in a vacuum; but is propelled into, and forcibly, and therefore injuriously, dilates them: the consequence is, the formation of a large quantity of frothy mucus. Whether the fall of temperature be owing to the evaporation of this copious secretion and its prevention of contact between the air and air-cells, or to the injurious nature of artificial respiration, still the fact ascertained by Le Gallois destroys the conclusion which appeared deducible from Sir B. Brodie's experiment. Indeed, Le Gallois found that less oxygen was consumed than in natural breathing, and that the temperature fell exactly in proportion to the smallness of the quantity of oxygen consumed. Dr. Crawford himself stated that the chemical process of respiration may, in certain cases, be the means of cooling the body. If the pulmonary exhalation, he said, is in very great abundance, it will carry off so much of the heat, given out during the change of the oxygen into carbonic acid, that there may not be sufficient to saturate the increased capacity of the arterial blood: this, therefore, will absorb caloric from the system, as it passes along, till its temperature equals that of all parts.[z] I may here remark, that the

[x] *Phil. Trans.* 1812. [y] *Expériences sur le Principe de la Vie.*

[z] *On Animal Heat,* p. 388. Instances are recorded by Morgagni (iv. xlix. 26.), and De Haen (*Ratio Medendi,* vol. iii. p. 36.), in the German *Ephemerides* (Dec. ii. Ann. iv.), and by Mr. Thackrah, of the blood which streamed down the extremity in venesection feeling cold to the patient and the practitioner. One woman compared it to ice; and the sensation given to Mr. Thackrah was the same as that of water at 68°. (Thackrah, *On the Blood,* p. 87.) In the *Ephemerides* the same is recorded of blood from the nose. The stomach of a cod was found by Dr. Mosely to be not only colder than the water from which it was taken, and the rest of the fish, but painfully to benumb the hand. (*Diseases of Tropical Climates.*) Similar observations were made at Newfoundland, and are quoted by Professor Rudolphi. (*Grundriss der Physiologie,* 182.)

temperature is kept down in a heated atmosphere by the diminution of chemical changes in the lungs, and by free secretion and evaporation from the bronchiæ and skin. How much each contributes is not ascertained; but the importance of evaporation was shown in some experiments of Dr. De la Roche, who raised the temperature of animals considerably by placing them in a heated atmosphere loaded with moisture; thus preventing evaporation. In a cold atmosphere, the chemical changes in the lungs are great, and the skin is dry: the aqueous matter which leaves the body then, does so chiefly by the kidneys, in a fluid form; and its amount is much less; because our thirst, and the amount of our drink, are much less.

Dr. Philip has made experiments equally conclusive with those of Dr. Le Gallois against the inferences drawn by Sir B. Brodie. As very little air is taken into the lungs in natural inspiration, and a regard to the bulk and frequency of each inspiration not always attended to in experiments, it is very probable that this gentleman had thrown too much air into the lungs; so that the unnatural quantity of cold air, and the augmented secretion of bronchial fluid, made the temperature fall. By impelling little, and that not frequently, Dr. Philip found that artificial respiration, after the destruction of the brain, actually retarded the cooling of the animal, while stronger respiration did actually cool the body.

Of two rabbits killed in this way, their temperature being 104°, one was subjected to 6 artificial inspirations, and the other to from 26 to 30, in a minute; the temperature of the former was 100° at the end of an hour, and the latter 98°. Of two, with the temperature of 102°·5, one was undisturbed, and one subjected to about 30 inspirations in a minute: the temperature of the former at the end of half an hour was 98°·75; of the latter, only 98°·5. But, the lungs of the latter being now inflated only about twelve times in a minute, the temperature of the former at the end of another half hour was 95°·25, and of the latter, 96°. In one experiment in which the lungs were inflated but a few times in a minute, the temperature actually rose nearly a degree by artificial respiration.[a] Dr. Hastings, at the same time, made similar comparative experiments, and with similar results. In one, the

[a] *An Experimental Inquiry into the Laws of the Vital Functions,* 3d edit. p. 180. sqq.

rabbit in which artificial breathing was performed cooled only 4° ; while that which was left undisturbed cooled 7°·5.

Dr. Philip afterwards took pairs of rabbits, killed them in the same way, and then in one experiment destroyed the brain and spinal marrow of one with a wire, while he left the other untouched: in another experiment, precisely similar, he inflated the lungs of both. Yet, in each experiment, they both cooled equally. In a third, the brain and spinal marrow of one only was destroyed, and the lungs of both inflated. These, too, cooled equally.

The temperature of fœtuses born without brain is maintained during the few days they may live.

Professor Rudolphi remarks that the temperature of animals bears no proportion to their nervous system: that, if it did, man should be warmer than any brute ; the mammalia much more so than birds ; fish much more so than insects ; and birds and amphibia nearly upon a par ; — all which would be the reverse of fact. [b]

Vegetables have a tendency to preserve a peculiar temperature, yet they have no nervous system.

But that the nervous system affects the temperature is certain. [c] A passion of the mind will make the stomach or the feet cold, or the whole body hot. Paralysed parts are often colder than others, or, more properly, are more influenced than others by all external changes of temperature. [d] But every function is affected by the mind, though not dependent upon the brain for its regular performance: and in varieties of temperature, both by the state of the mind and by paralysis, there is, as far as we can judge, a commensurate affection of the local circulation. Parts heated by any passion are also red, and *vice versâ ;* and paralytic parts must have imperfect vascular functions, in some measure, at least, from the want of the compression of the vessels by muscular action, and of the general excitement by volition; they waste, and sometimes inflame and ulcerate, or slough, on the slightest

[b] *Grundriss der Physiologie*, 150.

[c] " I have formerly treated at some length of the influence of the nervous system upon animal heat, in my *Specimen Physiologiæ Comparatæ inter animantia calidi et frigidi sanguinis*. 1786. p. 23.

See the same confirmed by many arguments in Magn. Ström, *Theoria inflammationis doctrinæ de calore animali superstructa*. Havn. 1795. 8vo. p. 30. sq. and by the much-lamented Roose, *Journal der Erfindungen, &c.* t. v. p. 17.

Consult also Dupuytren, *Analyse des Travaux de l'Institut*, 1807, p. 16."

[d] Dr. Abercrombie, *Edin. Med. and Surg. Journal.*

injury. Again, parts perfectly paralysed still maintain a temperature above that of the surrounding medium, as well as circulation, secretion, &c.[e], and sometimes the same as in health.

Dr. Philip considers galvanism an important agent in the nervous system, and found that it raised the heat of *fresh arterial* blood 3° or 4°, and, at the same time, made the blood dark; a circumstance proving that the action is purely chemical, — an alteration of some constituents of the blood to that state in which their capacity for caloric is less.[f]

There is certainly no more reason to believe animal heat dependent on the nervous system, than secretion and every organic function. That, like these, it is influenced by the state of the nervous system, is certain; but never, I imagine, except through the instrumentality of chemical changes.

The purpose of animal heat is no doubt the performance of the processes of the animated system, chemical, electrical, and vital, which cannot continue unless at a certain temperature, nor unless a certain degree of fluidity is preserved in some constituents of the system, and of solidity in others.

[e] Dr. Philip, we have seen, found rabbits just killed cool in exactly the same time, whether the brain and spinal marrow were destroyed or not, although when these were destroyed a stop was put to the secretion of gastric juice. Yet when the same was done to a living rabbit, with the same effect on the stomach, the animal's temperature fell. This, however, would result from the shock given to the nervous system as merely a part of the body, for the same happens every day in cases of severe injuries even of the extremities.

[f] *Experimental Inquiry*, p. 230. sqq.

Vegetables and animals are prepared for almost all climates, and for temperatures higher than the heat of any country. Dr. Reeve found larvæ in a spring at 208°; Lord Bute, confervæ and beetles in the boiling springs of Albano, that died when plunged into cold water. A species of chara will flower and produce seed in the hot springs of Iceland, which boil an egg in four minutes. (Drs. Hodgkin and Fisher's translation of Dr. Edwards's work, p. 467., where will be found many curious facts of this nature, though less striking.) One plant, *uredo nivalis*, which is a mere microscopic globule, is said to grow and flower under the snow.

Some cold-blooded animals bear heat very badly. Dr. Edwards says that frogs die in a few seconds in water at 107°. (l. c. p. 40.) Yet a species of tænia has been found alive in a boiled carp; but then the carp which it inhabits will live in water as hot as human blood. (Sennebier, Notes to his *Translation* of Spallanzani.)

The germs of many insects, &c. are unaffected by a great range of temperature. I know a gentleman who boiled some honey-comb two years old, and, after extracting all the sweet matter, threw the remains into a stable, which was soon filled with bees. Body lice have appeared on clothes which had been immersed in boiling water. Spallanzani found long ebullition in the open air favourable to the appearance of the animalcules of vegetable infusions; and the application of great heat in close vessels, although it prevented the appearance of a larger kind of animalcule, did not that of a smaller. The eggs of silk-worms and butterflies hatch after exposure to a cold of 24° below zero. On the other hand, insects may be frozen repeatedly, and recover as soon as thawed, as we shall see when speaking of torpidity.

Besides the power of generating heat, some animals are luminous, and some display great electric phenomena.

The glow-worm is known to all; and many insects of the beetle tribe, as well as others, emit light. Many can extinguish or conceal their light, or render it more vivid, at pleasure. In some it has been found to proceed from masses not dissimilar, except in their yellow colour, from the interstitial substance of the rest of the body, lying under the transparent integuments, and absorbed when the season of luminousness is passed. (Consult Kirby and Spence, *An Introduction to Entomology*, vol. ii. p. 409. sqq.) The ocean is frequently luminous at night from the presence of certain animalcules, to some sort of which, perhaps, is owing the phosphorescence of dead herrings. Some fish, as the gymnotus electricus and torpedo, give electric shocks, and possess a regular galvanic battery.

I have adopted the common language in speaking of animal heat, as though the phenomena depended upon a specific substance. However, there may be every reason to believe that neither caloric nor light are fluids, but peculiar states only; and electricity may prove to be so likewise; and, perhaps, all these to be modifications of the same state.

CHAP. XIV.

NUTRITION.

"Besides the function of distributing oxygen through the system, and removing carbon, the principal use of the blood is to afford nourishment to the body in general, and to the secreting organs the peculiar fluids which they possess the power of deriving from it. Nutrition shall be first examined.

"*Nutrition* is the grandest gift of nature, and the common and highest prerogative of the animal and vegetable kingdoms, by which they, beyond measure, surpass, even at first sight, all human machines and automatons. Upon these no artist can bestow the faculty, not to say of increasing and coming to perfection, but even of existing independently, and repairing the incessant losses incurred from friction.[a]

"By the nutritive faculty of the body, its greatest and most admirable functions are performed; by it we grow from our first formation and arrive at manhood; and by it are remedied the destruction and consumption which incessantly occur in our system during life.[b]

"Respecting the nature of this consumption, there has been much dispute whether it affects the solids[c], or whether, accord-

[a] "'Nutrition, in fact, appears to be a continued generation,' according to the old observation of the very ingenious Ent. See his work, already recommended."

[b] "Th. Young, *De corporis humani viribus conservatricibus.* Gotting. 1796. 8vo.

Fl. J. Van Maanen, *De natura humana sui ipsius conservatrice ac medicatrice.* Harderv. 1801. 8vo."

[c] "See the great J. Bernouilli's *Diss. de nutrit.* Groning. 1669. 4to. He estimates the continual, though insensible, loss and reparation of the solids so high, that the whole body may be said to be destroyed and renewed every three years."

ing to some very acute writers [d], these, when once formed and perfected, remain invariably entire.

"There can be no doubt that some of the similar solids, *v. c.* the epidermis and nails, are gradually destroyed and renewed; the same is proved by the frequently surprising attenuation of the flat bones, especially of the skull, from defective nutrition, in old age [e]; and" some imagine "it is proved also by the well-known experiment of dyeing them, in warm-blooded animals, with madder root."

But the redness imparted to the bones by feeding animals with madder, does not prove that the matter of the bones is constantly changing; because the opinion that the madder unites with the phosphate of lime in the blood, and thus reddens all the bony matter subsequently deposited, is erroneous. Mr. Gibson proved, by numerous experiments, that the serum has a stronger affinity than the phosphate of lime, for madder. The serum being charged with madder, the phosphate of lime of the bones, already formed, seizes the superabundant madder, and becomes red. If the madder is no longer given to the animal, as it is continually passing off with the excretions, the stronger attraction of the serum draws it from the bones, and they re-acquire their whiteness. [f] The attenuation of the flat bones shows, I imagine, wasting only.

The constant renewal of the epidermis is demonstrated by wearing black silk stockings next the skin. The microscope exhibits that very minute fragments are incessantly thrown off from the mucous membranes no less than from the skin. [g] That the hair and nails not only grow perpetually, but are even reproduced, is certain from the great quantity of the former which falls off the head *whole* if worn long, while a good head of hair still continues; and from the renewal of the latter, after the loss of a great part of a finger. I once attended a middle-aged woman in St. Thomas's Hospital, who had lost nearly the whole of the first phalanx of a finger, and yet the stump was tipped by

[d] "See J. Chr. Kemme, *Beurtheilung eines Beweises vor die Immaterialität der Seele aus der Medecin.* Halle. 1776. 8vo.

And his *Zweifel und Erinnerungen wider die Lehre der Aerzte von der Ernährung der festen Theile.* Ibid. 1778. 8vo."

[e] "Respecting this mutability of the bones, I have spoken at some length in my osteological work, ed. 2. p. 26. and elsewhere."

[f] *Manchester Memoirs*, vol. i.

[g] Raspail, l. c. pp. 245. 505.

a nail, though certainly a clumsy one. An instance of a nail at the end of the stump, after the complete removal of the first phalanx, may be seen in one of our London Journals.[h] Tulpius declares he has seen examples after the loss of both the first and second phalanges — in secundo et tertio articulo.[i] The glans penis (in truth a mere continuation of the corpus spongiosum urethræ) was entirely renewed in one case.[k] Nothing more can, I apprehend, be said respecting the entire restoration of organs in the human body. Portions of cutis, bone, membrane, blood-vessels, absorbents, and nerves, are replaced. That portions of large nerves, fully capable of all the functions of the destroyed pieces, are reproduced, is now a matter of certainty.[l] Minute blood-vessels and absorbents are of course allowed on all hands to be produced in the cure of most solutions of continuity, whether by wounds, ulceration, or whatever else[m]; but Dr. Parry, senior, has shown, that, in the ram, at least, when a blood-vessel which proceeds some way without giving off a branch is obstructed, new branches sprout forth and establish a communication on each side

[h] *London Medical and Physical Journal*, 1817.

[i] *Observationes Medicæ*, iv. 56.

[k] *Edinburgh Med. and Physical Essays*, vol. v.

[l] The proofs of this are numerous; the latest are by Tiedemann. *Zeitschrift für Physiologie*, 4ter band, 1ter heft, S. 68.

[m] Mr. Bauer thinks he has observed vegetable tubes to be constructed by the extrication of carbonic acid gas into a slimy matter prepared for nutrition. Some such opinion was held by Borelli, Tabor, and Hales. He explains the formation of blood-vessels in coagulated fibrin and pus in an analogous manner, but his experiments did not proceed far enough for me to dwell upon them. *Phil. Trans.* 1818 and 1819. Dr. Stevens has recently made observations upon this subject. (l. c. p. 66.)

Not only divided parts re-unite, but even portions completely separated and cold, and parts of different bodies. A soldier's arm was struck off at the battle of Arlon, with the exception of a piece of skin and the subjacent vessels and nerves, and yet the muscles, bones, &c. completely re-united in about eight months. (*Dictionnaire des Sciences Médicales*, t. xii.) Garengeot saw a nose unite after being bitten off, trampled upon, and allowed to lie in the dirt till it was cold. (*Traité des Opérations de Chirurgerie*, t. iii.) Dr. Balfour saw a similar occurrence in the instance of a finger. (*Edinburgh Med. and Surgical Journal.* 1815.) One will be found (Rust's *Magazin*, 14 b. 1 h. p. 112. Berlin, 1823.) by Dr. John, *Wiederanheilung eines gänzlich absgeschittenen fingers.* Others might be quoted. See Dr. Thomson's *Lectures on Inflammation*, p. 243.

Transplantation, for instance, of the cock's testes to the hen's abdomen, as well as of the spur to the head, is very common, and the latter was mentioned nearly two centuries ago in Bartholin, *Epist.* Cent. i. p. 174.; and by Duhamel, in the *Mém. de l'Acad. Royale des Sciences*, 1746, as very common in poultry-yards.

of the obstruction.[n] The continuance of circulation was previously attributed solely to the enlargement of the small anastomosing vessels; and we know that whenever the aorta itself is obstructed, branches will so enlarge as to carry on the circulation very well.[o] Muscle is supplied by tendinous matter. The substance formed in the situation of destroyed cellular membrane is so little cellular, that it does not become distended in emphysema or anasarca.[p]

" If I am not mistaken, those solid parts undergo successive change, which possess the *reproductive power*, — an extraordinary faculty, by which not only the natural loss of particles, but even the accidental removal of considerable parts through external injuries, is repaired and perfectly supplied, as the bones[q] and a few other parts sufficiently demonstrate.

" In those parts whose vital powers are, as it were, of a higher order, the parenchyma, constituting their base, appears permanent, and is liable to this change only, — that the interstices of the fibres and parenchyma, while nutrition is vigorous, are constantly full of nutrient animal ". soft substance ; " but, when nutrition languishes, are deprived of this, collapse, and consequently become thin." The very convolutions of the brain will shrink in extreme emaciation.

" During the growth of the body, peculiar powers are exerted, by which the fibrin deposited in the cellular membrane from the blood-vessels is properly distributed and intimately assimilated to the substance of each organ, &c.

[n] *An Experimental Inquiry, &c.* See also Dr. Charles Parry's work, in which similar experiments are related.

[o] See a case in the *Dublin Hospital Reports,* vol. ii. *Med. Chir. Trans.* vol. v.

[p] Dr. Thomson, *Lectures on Inflammation,* p. 417.

[q] " Consult, among others, G. L. Koeler, *Experimenta circa regenerationem ossium.* Gotting. 1786. 8vo.

Alex. Herm. Macdonald, *De necrosi ac callo.* Edinb. 1799. 8vo "

" That the corium is not really reproduced, is probable, not only from its perpetual *cicatrices* (for some contend that the *matter* of these does not continue, but their *form* only, which is preserved by a perpetual apposition of fresh particles in the room of the decayed and absorbed), but much more by the lines and figures which are made upon the skin by the singular art of pricking it with a needle (a process denominated in the barbarous language of the Otaheiteans *tatooing*), and imparting to the corium a blue or red colour, as permanent as the cicatriculæ, by means of charcoal powder, ashes, soot, the juices of plants, or ox-gall ; while, on the other hand, the red hue imparted to the bones, by means of madder, quickly disappears, as these parts undergo a continual renovation."

" This is referable both to the laws of affinity " and repulsion, " by the former of which we imagine particles attract and, as it were, appropriate others which are similar and related to themselves," while by the latter others are cast off; and to the peculiar powers of life which only can effect " the proper application of shapeless elementary matter, and its modification to particular forms." The blood contains either the principles themselves of various solids, or principles readily converted into them by chemical change. For instance, we know how readily a portion of it grows solid out of the body; and the albumen of the egg is at first almost entirely fluid, but gradually a portion of it becomes insoluble [r]; we see mucus expectorated sometimes of great consistence, though it must have been poured forth fluid. Farther, the fluids of the egg, after the influence of the fluid of the male, solidify by themselves, and at length form an animal. A coagulum of blood will of itself become vascular, and be converted into an organized solid. Such are facts of formation, and we can have less difficulty in conceiving that the fluids brought into proximity with solids unite with them in the case of nutrition. We know also that gelatine enters into the composition of every part, and that the skin is little else, whereas the blood contains none : but then gelatine differs from albumen, in only containing three or four per cent. less carbon, and carbon is thrown off from the body incessantly.

" The union of both these powers, we conceive, must be the source of the nutrition of such similar parts as are not supplied with blood itself, but are, nevertheless, at first generated by a most powerful and infallible nisus, grow, are nourished throughout life, and, if destroyed by accident, are very easily reproduced. [s]

" As this appears to be the true account of nutrition in general, so, on the other hand, this function evidently has great varieties of degree and kind," generally and locally, " especially where, from the more or less lax apposition of the nutritious matter, the structure of the similar parts is more or less dense, and the specific weight of the whole body more or less considerable.[t] In this

[r] M. Raspail, l. c. p. 194.

[s] " *Zwo Abhandlungen über die Nutritionskraft welche von der Acad. der Wiss. in St. Petersburg den Preiss getheilt erhalten haben.* Petersburg. 1789. 4to.

De Grimaud, *Mémoire sur la nutrition qui a obtenu l'accessit.* Ib. same year. 4to.

Steph. J. P. Housset, on the same subject (in the same school) in his *Mémoires physiologiques et d'hist. naturelle.* Auxerre. 1787. 8vo. t. i. p. 98."

[t] J. Robertson, On the specific Gravity of living Men. *Phil. Trans.* vol. l. P. i. p. 30. sq.

respect, not only individuals, but whole nations, differ from each other. The Yakuts and Burats, who are remarkable for the lightness of their bodies, are a sufficient example of this."

A certain degree of excitement and use causes parts to be better nourished, so that the exercise, for instance, of muscles, is seen to render them larger, and disuse to cause them to waste. Great excitement and excessive use exhaust and also occasion a part to waste. Organs, or some one or more of their component tissues, will, without very clear reasons, sometimes be over-nourished, hypertrophied; or under-nourished, atrophied; and different tissues of the same organ are sometimes oppositely affected. Nutrition is sometimes perverted, so that consistence, or even texture, is changed. Occasionally the structure of a part is changed to that of some other part — is transformed: and occasionally structures are produced altogether foreign to the body.

" Brutes far surpass man in both the ordinary renewal of the integuments and appendages, and in the extraordinary restoration of destroyed organs. The horse periodically sheds its hair, the bird its feathers [u], the stag its horns, the serpent its cuticle, the lobster its shell and the teeth which are in its stomach.[x] The fall of the leaves of trees is an analogous circumstance. Insects not only change their coats frequently, but undergo complete metamorphoses; are first worms, then grubs, and finally winged beings. The crystalline lens extracted from a healthy eye is speedily reproduced in cats, dogs, and rabbits [y], and probably in other brutes. The extraordinary reproductive power of some brutes is almost incredible. A lobster can reproduce a claw; a water-newt an extremity: Blumenbach actually observed the reproduction of the whole head with its four horns in a snail, and the complete eye — cornea, iris, crystalline lens, &c. — in a water-newt.[z] Besides greater powers of reproduction than man, brutes generally possess greater also of reparation — will survive injuries which would prove fatal to us, perhaps under any circumstances, or at least without great care. I related Brunner's numerous attempts upon the life of a dog, of which, violent

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[u] Feathers which are not cast off, have been discovered to receive an increase of colour at the moulting season. *Linnæan Transactions.* 1818.

[x] This corroborates the propriety of the view taken by Dr. Prout in an unpublished paper written many years ago, in which he contends that the teeth are to be arranged with the integuments. A similar opinion has been lately published in France.

[y] MM. Cocteau and Le Roy d'Etiolle. Magendie's *Journal de Physiologie.* Janvier, 1827.

[z] *Göttingen Literary Notices.* 1787. pp. 28. 30.

as they were, " vim elusit, vegetusque evasit," as an illustration of this. Less violent injuries are recovered from with far less danger and inconvenience than we experience. The lower we descend into the scale, the greater tolerance of violence and the greater powers of reparation and renewal do we observe. When a salamander's head has been cut off, the wound has healed. (Dr. Edwards l. c. p. 11.) If the head of a planaria from our ponds is divided longitudinally a certain way, the wound heals: if completely, other new matter will be deposited and join the two heads into one of great size, with one or two additional eyes; or each half will become a new head. If the whole body is divided, except at the tail, Siamese twins are made, which pull discordantly and tear asunder their bond of union, and become independent. Not only does a planaria acquire a new head after decapitation, but, if the two heads which have been produced by division are removed, others have sprung up three times in succession, and, the animal being then divided throughout and its head cut off, one head only was now produced. If the animal is divided across, the anterior half swims off, and even sends forth a tail: the tail sinks, but after a few days sends forth a head. If cut across into three, the anterior and posterior proceed thus, and the middle part shoots forth both a head and tail. Nay a planaria has been cut into ten pieces, and each has become a perfect animal. (Dr. Johnson, *London Medical Gazette,* Feb. 10. 1832.) Some mites live in alcohol, and flies have come to London in a pipe of Madeira and revived. I have soaked a caterpillar in Scheele's prussic acid, and seen it recover in half an hour. If the polype, which is a gelatinous tube, with one end closed and the other fringed for the purpose of receiving food and conveying it, is divided, the two halves change at one end, the one closing, the other acquiring fringes, so that both halves become perfect animals; or, if a polype is inverted, the outer surface forms a digesting cavity.

Vegetables endure extreme violence. A log of mulberry-tree has sent forth shoots on being placed in the ground as a post, after many years of neglect; a gooseberry-bush will grow if planted with its branches in the earth and its roots in the air.

CHAP. XV.

SECRETION.

"Besides the products of nutrition, *fluids* of extremely various descriptions are produced from the blood by means of *secretion*, which Haller, no less than his predecessors, with truth and regret declared to be among the most obscure parts of physiology."[a] While nutrition is the production of the component solids from the blood, secretion is thus the production of fluids from it, by vital processes. The nature of the process in both must be the same. The solid products of nutrition are also said by many to be first deposited in a fluid state.

"The secreted fluids differ, on the one hand, so considerably among themselves, and, on the other, have so many points of resemblance, that their classification cannot but be extremely arbitrary. If we arrange them according to the degree of difference between them and the blood from which they are formed, they will stand in the following order:—

"First, the *milk*, which may be in some degree considered as chyle reproduced, and appears formed by the most simple process from the blood newly supplied with chyle.

"Next, the *aqueous* fluids, as they are commonly denominated from their limpid tenuity, although the greater part differ importantly from water in the nature of their constituents, and especially in the proportion of albumen: such are the humours of the eye, the tears, in all probability the vapour contained in the cellular interstices and the cavities of the abdomen and thorax; nearly similar, also, is the fluid of the pericardium and of the ventricles of the brain." They contain mucus, soda, hydrochlorates, and phosphates.

[a] "Fouquet on Secretion, in the Encyclopedical Dictionary of Paris, t. xiv.
Fr. L. Kreysig, *De secretionibus*. Sp. i. ii. Lips. 1794. sq. 4to.
Ignat. Döllinger, *Was ist Absonderung, und wie Geschieht sie?* Herbipol. 1819. 8vo."

"The liquor amnii of pregnancy, and the *urine*, remarkable for the peculiar nature and mixture of its proper constituents, are generally enumerated among these.

"The *salivary fluids*, concerned in mastication, digestion, and chylification, appear more elaborated.

"Next the *mucous*, which line the cavities of most of the organs performing the natural and genital functions, and likewise the tract of the nostrils, larynx, and trachea.

"The mucus within the eye, and under the epidermis, is nearly similar.

"In the same class may be included the cerumen of the ears, the unguent of the Meibomian glands and of the joints, and, perhaps, the ambiguous and nameless fluid commonly poured forth by the vagina during the venereal œstrum." Mucus contains an abundance of hydrochlorate of soda, and differs in different parts. That of the nostrils and bronchiæ at first coagulates in nitric acid, and at last dissolves; that of the gall-bladder coagulates by acids and alcohol; that of the urine coagulates by tannin, but not by acids, is very soluble in alkalies, and dries red.

"The *adipose* are, besides the common fat, the medulla of the bones and grease of the skin.

"Related to these are the secretion of the corona glandis under the præputium, and of the external female genitals.

"The truly *serous*, or albuminous, are the fluid of the ovarian vesicle of De Graaf, and the liquor of the prostate.

"The *semen virile* and the *bile* are each *sui generis*." [b]

[b] Dr. Bostock arranges the productions of nutrition and secretion as the *aqueous*, *albuminous*, *mucous*, *gelatinous*, *fibrinous*, *oleaginous*, *resinous*, and *saline*. (*An Elementary System of Physiology*, vol. ii. p. 329. sq.)

The *aqueous* are the perspiration and pulmonary halitus, in which the proportion of water is so great as to give the chief character.

The *albuminous*, — all the membranous or white parts of animals, the fluids of serous membranes and of the cellular membrane, the former differing from the albumen of the blood chiefly in being freed from extraneous matter and coagulated; the latter from serum, chiefly in containing much less albumen.

The *mucous* are the mucus of all mucous membranes, the saliva, gastric juice, tears, and semen. The animal matter which is their basis much resembles coagulated albumen, and their salts are neutral, while those of the albuminous fluids are alkaline.

The *gelatinous* are named from containing jelly, — a substance not found in the blood nor any of the fluids, but abundantly in membranes, and particularly in the skin; and as albumen may be converted into it by digestion in dilute nitric acid, it appears to be the albumen of the blood with an addition of oxygen

Berzelius adopts the old division of secretions and excretions, and makes the following remarks : —

" There are two classes of secreted fluids, viz. the *secretions* properly so called, or the fluids intended to fulful some ulterior purpose in the animal economy, and the *excretions*, which are directly discharged from the body. The fluids of the former class are all alkaline, and of the latter all acid. The excretions are the urine, the perspired fluid, and the milk. All the other fluids appear to belong to the former class.

" The alkaline secreted fluids may be divided into two very distinct species. The former of these contains the same quantity

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and a diminished proportion of carbon. It abounds in the young, so that those parts, which at the beginning of life are almost entirely jelly, consist chiefly of albumen as age advances : since it is not found in the fluids, it must be supplied with its carbon again, and is, probably, reduced to the state of albumen. Dr. Prout considers gelatine the most imperfect form of albuminous matter — and the counterpart of the saccharine principle of vegetables.

The *fibrinous* are the muscular fibres, abounding in azote, and thus more completely animalised, resembling the fibrin of the blood, — apparently their source.

The *oleaginous* are the fat, marrow, and secretions of sebaceous glands, and perhaps the milk, as its properties depend so considerably upon oily matter.

The *resinous* are the bile, cerumen, and urea, very similar to the former, but owing their specific characters to a kind of resin. Osmazome is referred to this class ; but what M. Raspail thinks of it was mentioned under the head of blood.

The *saline* are the acids, alkalies, and neutral and earthy salts of the various solids and fluids ; generally more copious in the fluids than in the solids, absent in the simple oleaginous secretions, and abundant in the compound ; and still more so in the resinous secretions. Their quantity is greatest in the bones, which are principally phosphate of lime ; but, with this exception, the urine possesses the greatest proportion, as well as the most variety. 1. In some secretions they are absent ; as the fat. 2. In some they exist in definite quantity, and this different from that in the blood ; as the saliva. 3. In others, they are found in the same quantity, and of the same nature, as in the blood ; such is the fluid of serous membranes. 4. In some, they are different from the salts of the blood, and of variable quantity ; as the urea. These four divisions are — i. The solid and albuminous, the gelatinous, and simple oleaginous. ii. The mucous, fibrinous, compound oleaginous. iii. The liquid albuminous. iv. The aqueous and resinous.

This arrangement is certainly good ; but, like every artificial arrangement of natural objects, convenient for general views and memory, rather than correct. For example, the semen is mucous, but unlike every other fluid : the gastric juice and cerebral substance are equally *sui generis*. Fibrinous matter as well as mucus exists in semen, and is probably, indeed, its specific part : albumen exists abundantly in milk, united into an emulsion with the oleaginous portion. The bile and urine have few properties in common ; and urea is certainly not a resinous substance.

of water as the blood, so that the change induced by the nervous influence seems to be confined to that of altering the chemical form of the albuminous materials[c], without affecting their relative proportion to the water and other substances dissolved in the blood. The bile, spermatic fluid, &c. are of this kind. The latter species consists of fluids, in which the influence of the nervous system has separated a large portion of the albuminous matter, and left the remaining liquid proportionally watery. The saliva, the humours of the eye, and the effused serum of membranes are of this species; and in these the quantity of salts, and in general also of alkali, is the same as in the blood.

"The influence of the chemical agent of secretion is, therefore, chiefly spent upon the albuminous materials of the blood, which seem to be the source of every substance that peculiarly characterises each secretion, each of which is *sui generis*, and is its principal constituent. All the other parts of the secretion seem to be rather accidental, and to be found there only because they were contained in the blood out of which the secretion was formed. Therefore, in examining the secreted fluids, the chief attention should be paid to the peculiar matter of the fluid, which varies in all. This matter sometimes retains some of the properties of albumen; at other times, none; and hence an accurate analysis, showing the quantity and nature of this peculiar matter, is above all to be desired.

"If the several secretions be supposed to be deprived of their peculiar matter, and the remainders analysed, the same residue would be found from them all, which also would be identical with the fluid separated from the serum after its coagulation. Thus we should find, first, a portion soluble in alcohol, consisting of the muriates of potash and soda, lactate of soda, and of an extractive animal substance, precipitable by tannin; and, secondly, of a portion soluble only in water, containing soda (which acquires carbonic acid by evaporation, and is separable by acetic acid and alcohol) and another animal substance, not extract, precipitable from its solution in cold water, both by tannin and muriate of mercury. Sometimes a vestige of phosphate of soda will also be detected.

"The excretions are of a more compound nature. They all contain a free acid, which is termed lactic, and in the urine this

[c] This appellation Berzelius gives to the fibrin, albumen, and colouring matter of the blood.

is mixed with the uric acid. Urine seems to contain only a single peculiar characteristic matter; but milk has as many as three, viz. butter, curd, and sugar of milk, which, however, seem to be produced by different organs that mingle their fluids in the same receptacle. The perspired fluid appears to have no peculiar matter, but to be a very watery liquid, with hardly a vestige of the albumen of the blood, and, in short, is the same as the other excretory fluids would be when deprived of their peculiar matter. If we suppose this matter taken away from those excretions which possess it, the remaining fluid will be found to have properties very different from the fluid part of the secretions, when equally freed from their peculiar matter. That of the excretions is acid, contains earthy phosphates, and when evaporated, leaves a much larger residue than the fluid of the secretions. This residue is yellowish brown, of the consistence of syrup, with an unpleasant, sharp, saline taste of the salt that it contains. It reddens litmus, is most soluble in alcohol, and this spirituous solution contains the muriates of the blood, together with free lactic acid, much lactate of soda (the soda being the free alkali of the blood, neutralised by this acid), and the extractive matter, which always accompanies this neutral salt. The part insoluble in alcohol contains a distinguishable quantity of phosphate of soda, a little of a similar animal matter to that found in the secretions, and also the earthy phosphates which were held in solution by the lactic acid, and were precipitated by the action of the alcohol. The urine possesses also a number of other substances, which will be specified when describing this secretion in particular." [d]

The most simple mode of secretion is where the ordinary arteries in the neighbourhood ramify on a surface, as on the skin, mucous or serous membranes, and the fluid is poured forth *upon* it. The next mode is where the arteries ramify on the inner surface of a cup, called a cell or crypt, *into* which the fluid is poured, and in which it remains a longer or shorter time and becomes more consistent. The next is where this cup is so lengthened that it becomes a pouch or follicle. If prolonged still more, it is a canal, of various lengths. Next, what is termed a gland, is but a conglomeration of numerous canals, beginning each from a blind extremity and uniting together till they form one tube only, which opens upon some surface under the name of

[d] General Views of the Composition of Animal Fluids, by J. Berzelius, M.D. *Medico-Chirurgic. Trans.* vol. iii. p. 234.

excretory duct. Anatomists formerly supposed that the ducts of glands were, like veins, merely prolonged arteries, except, of course, where, as in the case of the liver, the secretion takes place by a vein. But Dr. Mueller, of Bonn, in a most elaborate work [e], in which he demonstrates this to be the structure of all glands in all animals, contends that the arteries ramify on the inner surface of the canals as upon any membranes, and, after forming a network, terminate in veins; so that the fluid secreted passes into the secretory ducts, which are in truth all excreting, just as we see it poured upon serous and synovial membranes. The excretory ducts of glands, therefore, precisely resemble the trachea, which divides and subdivides till it ends in blind twigs of extreme minuteness. Indeed, the extremities of the twigs of the ducts of the salivary glands of some animals are enlarged into a globular form, so that the woodcut which illustrates the air cells at the extremities of the bronchial twigs, might be taken for a delineation of the extremities of the salivary ducts of the sheep, for example, as may be seen in Dr. Mueller's sixth plate. Thus it would appear that all secretion is of that kind to which old physiologists gave the name of diapedesis or transudation, in which the fluid is supposed to be merely strained through the sides or open mouths of the vessels, and upon which Blumenbach remarks, that "physiologists have lately given different explanations of this mode of secretion. Some assert that every fluid is formed by passing merely through inorganic pores from the blood: others altogether deny the existence of these pores. I think much of this is a verbal dispute. Because, on the one hand, I cannot imagine how *inorganic* pores can be supposed to exist in an *organised* body, for we are not speaking here of the common interstices of matter, in physics denominated pores; and I am persuaded that every opening in organised bodies is of an organic nature, and possesses vital powers exactly correspondent. On the other hand, these openings or pores, which indisputably exist in the coats of vessels, I think but little different, in function at least, from the cylindrical ducts through which fluids are said to percolate in conglomerate glands and secreting viscera: for this percolation depends less on the *form* of the organ than on its *vital powers*." [f] But Dr. Mueller asserts that

[e] *De glandularum secernentium structura penitiori earumque prima formatione in homine atque animalibus.* Lipsiæ. 1830. folio.

[f] "Consult, among others, Schreger, *Fragmenta,* p. 37. sq. already recommended.

no openings exist; that the capillary blood-vessels, which form a network upon the inner surface of the secretory canals, do not secrete, but continue perfect canals till they become veins; and that the membrane itself, imbibing the blood and changing its fluid portions, pours this forth from its own substance upon its surface, and the secretion is performed not only at the extremities of the canal, but throughout it.

I agree, however, with those who believe that the new fluid is not formed by the substance of the walls of the canals, but passes formed from the minute twigs of the blood-vessels upon its surface; and I think, with Blumenbach, that the infinitely minute spaces, through which the fluid oozes into the secreting canals, must be regarded as living, not inorganic, pores. For, as I have already stated (p. 133.), the imbibition observable after death is not found to occur during life. In the next place, a secretion is not only increased by supplying the blood with more of the materials furnishing it, and vitiated by vitiating the blood, but may be rapidly and greatly augmented or altered without any augmentation or alteration of the materials in the vessels, merely by the administration of particular stimuli in minute quantity, or by emotions of the mind. Healthy secretion must be a living process, performed by living solids, and the minute spaces through which this secreted fluid moves, are spaces bounded by living solids, are apertures in living solids, and therefore not inorganic pores. Indeed, although it has been proved that glands are ducts beginning by blind extremities, and not prolonged from blood-vessels, and have their blood-vessels ramifying on their inner surface, I am not satisfied of the existence of proof that these blood-vessels transmit their fluid into the canal through apertures in their sides, and not by infinitely minute twigs with open mouths. As absorption takes place by the open mouths of vessels, secretion probably does the same. But whether these are mere apertures, or from these apertures the vessel is a little prolonged in the form of a minute twig, still the openings are in living solids, and therefore must be subject, like all the visible openings in the body, to the laws of life. If it is the

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P. Lupi, *Nova per poros inorganicos secretionum theoria refutata, &c.* Romæ, 1793. 2 vols. 8vo.

Kreysig, *Specimen Secundum;* formerly recommended.

Also C. Le Gallois, *Le sang est-il identique dans tous les vaisseaux qu' il parcourt?* Paris, 1802. 8vo."

substance of the sides of secreting canals that secretes, still it must secrete from fluid poured into it from blood-vessels. The contents of these vessels is blood. But it is not likely that blood oozes through the sides of its vessels, nor that the substance of a secreting canal has blood diffused in it. It is more likely that minute twigs arise from blood-vessels, and, being of a peculiar nature, admit only certain parts of the blood, which they change and transmit through open mouths into the secretory substance of the canal; or, that *living* openings exist in their sides that will permit the exit of only these certain portions of the blood, and these portions are poured forth into the substance of the sides of the secreting canal to be farther elaborated. But, on either supposition, the opening of the blood-vessel into its twig, or, if there be no twig, into the substance of the sides of the secreting canal, must have a living margin. Dr. Mueller, however, contends that the minutest streams of blood are contained in solids scarcely more dense than the blood itself, — in boundaries which are not vessels, but mere furrows, and so slightly different from the fluid blood, that this freely mingles with them and is changed into them or various new products. Unquestionably the minutest parts, and those which are the fundamental portion of the rest, are, like the embryo frame, of exquisite delicacy and softness. If we remark that the smallest artery of fins and webs may, under the microscope, be seen terminating in veins, and giving off minute vessels which run to veins, not colliquescing into a pulpy substance; we receive this reply, — that the minutest arteries must be pulpy enough to allow the blood to mingle with their substance. Yet the effect of emotions and certain articles is more explicable on the idea of organic openings and canals.

If Dr. Mueller is correct in supposing that the substance of the tubes secretes from *blood* poured into them, still I would contend that the blood passes into them through organic openings in the blood-vessels; and the fluid produced cannot pass from the substance through inorganic pores, because, being mixed with blood, or what is left of the blood, inorganic pores would transmit both. Again, what is left of the blood, after the separation of the new fluid from it, must be taken back, and we cannot suppose it to pass again through inorganic pores into the blood-vessels. Openings in them must have a power of selection, or the secreted fluid would equally pass back; and, if absorbents take up what is left, not mere organic *openings* but vessels are brought into play in the

business; and vessels may as well be presumed to have also carried the secreted fluid from the blood. Indeed, that the secretion takes place in vessels, is proved, if an author is correct in asserting that the formation of the new substance within the vessels may be demonstrated "by forcing coloured injections into the arteries of growing bones, when the lime is seen to issue from their orifices in the form of a white powder, and deposit itself, like the farina of a flower, for the office of consolidation. In a similar way, the injected arteries of the common domestic hen, while her eggs are incomplete, will show the deposition of lime from their exhalant branches upon the membrane which afterwards becomes the shell." [g]

Some have thought no organic opening necessary, because the changes in the blood of the lungs take place through membrane. But the separation of carbonic acid is a mere physical or chemical occurrence, not a secretion, and takes place equally in dead blood, through dead membrane. The entrance of oxygen into the blood might be equally alleged as an argument against the existence of absorbent vessels on surfaces.

Just as solids are not originally firm, nor exactly of the nature they are when their texture is perfect, but the soft substance, which is their elementary portion, hardens by subsequent changes; so the fluids which pass from the blood-vessels are probably more and more changed, till they ooze perfect into the secreting canal. Even after this they become more consistent, as may be seen in mucus which has lain upon a mucous membrane, or the bile which has been in the gall-bladder.

The difference between nutrition and secretion is, that, in the former, the fluid does not pass away, but remains and coheres to the solids, and, undergoing further changes, solidifies, and becomes part of them.

The secreting surface of a gland must be very extensive. The blind extremities are of endless forms. Not only are some mere cups or crypts; some longer, so as to be pouches; some longer still, so as to resemble a portion of blind intestine; some, again, extremely long canals, of the same diameter throughout their course [h]: but any of these may be single or aggregated, and

[g] *A View of the Structure, &c. of the Stomach, &c.* By Thomas Hare, F.L.S. London, 1821. p. 77.

[h] "Malpighi, in works repeatedly quoted, and also in his *Diss. de glandulis conglobatis*, Lond. 1689, 4to, (but consult especially his *Opera Posthuma*, ib. 1697,

variously diversified, complicated, and arranged, and collected into a small space, so as to resemble vegetable forms, and be as various. These all consist of a single membrane, belonging to the class of the mucous; with some of which, indeed, it usually at last becomes continuous. When the conjunction of tubes has produced the portion called excretory duct, one or more additional coats unite with the essential membrane. The secreting membrane is always white, whitish grey, or whitish yellow, whatever the colour of the fluid secreted. Very different secretions are produced by glands of similar structure, as by the kidneys and testes; the same secretion is produced by very different structures in different animals, as the saliva, bile, urine, and semen. Some appear to require an immense surface to produce a given quantity; others one not of great extent. The secreting surface of the vessels, which by their union form the hepatic duct, must be immense: the gastric juice proceeds from the limited inner surface of the stomach; and this shows also that, for an important secretion, no gland, that is, no tube, or aggregation of tubes, is necessary. The saliva, on the other hand, is produced by several elaborately formed glands. Complexity of gland merely implies a greater extent of secreting surface; a larger number of canals being aggregated, or longer canals coiled up together. Amount of secreting surface is, of course, proportionate, not merely to the complexity of the tubes, but to the bulk of the whole organ.

The most elaborate fluids, as the semen, bile, urine, are produced by the most complicated glands, that is to say, such

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fol.; and published likewise elsewhere,) considered the miliary globules, which are easily discoverable in most glands, as acini, according to his expression, internally excavated," and having arteries open into them and excretory ducts begin from them to carry off the fluid first poured forth from the arteries and then fully elaborated in the acini. "Ruysch, on the contrary, contended that these supposed hollow acini were nothing more than glomerules of blood-vessels" which were continued into the excretory ducts. The acini are merely the blind extremities of ducts, and the blood-vessels, conglomerated into granules, as we saw when considering the liver. Duverney (*Comment. Ac. Sc. Petrop.* 1750.) showed that the lactiferous ducts of the hedgehog began as vesicles arranged like a bunch of grapes. Mascagni and Cruikshank afterwards demonstrated the same in the human breast, and Mascagni admitted that the excretory ducts began as blind extremities and had no arteries opening into them. He assumed the existence of inorganic pores. Dr. Mueller justly proposes to banish the term acini altogether, and speak only of the elementary parts of glands or blind beginnings of the secreting tubes.

fluids appear produced in small quantity from a given surface; and a fluid nearly aqueous, or at least with no peculiar constituent, is produced from so small a surface as that of a mucous or serous membrane, or crypts or follicles. Whatever may be the constituents of the fluid, if they are secreted with a large quantity of water, the complexity and bulk are not in proportion to the quantity of such secretion. For instance, the urine far exceeds the bile in quantity, yet the two kidneys together are not more conglomerated, and are smaller, than the liver; for the elaborate contents of the urine are greatly diluted with a fluid which requires no extent of surface for its production. I should, perhaps, say that the elaborate nature of a secretion, its amount, and its concentration, are all elements that require a more extensive secreting surface; and this is given by both complication and amount of canals, so that the relations of a secretion and the secreting organs depend not on one, but the whole, of these points. As a connection of peculiarity of secretion with peculiarity of structure cannot be discovered, the cause of such secretion must be certain unknown powers of the secreting organs, as inexplicable as the powers of formation and the powers of nutrition.

It is of no consequence, in the case at least of some organs, by what vessel the blood is conveyed to the secretory apparatus. Mr. Hodgson, on opening the body of a diabetic person, found the cavity of one renal artery obliterated by an accumulation of atheromatous and calcareous matter in its coats. The glandular structure was perfectly natural. The pelvis contained urine, and a considerable quantity of that fluid was found in the bladder. The kidney was supplied with blood by a large branch from one of the lumbar arteries and by the arteries of the renal capsule.[i] Dr. Andral once found a kidney in the pelvis, and supplied by the hypogastric artery.[k] When a breast which secreted good milk is situated on the thigh, we have another illustration of the same fact.

The quality of the blood, however, from which the part has to fabricate the new substance is important. The liver is supplied with venous blood as the material, and so are the kidneys of amphibia. We cannot suppose that arterial blood would have been suitable. For other secretions dark blood is unsuitable. Various

[i] *A Treatise on the Diseases of Arteries and Veins, &c.*

[k] *Précis d'Anat. Pathol.* t. ii. P. ii. p. 628.

secretions, and the quality of the solids of the body, are affected by the quality of the food and the absorption of different substances that alter the blood. Dr. Wollaston found the urine of birds to be nearly pure uric acid, if animal food only was taken.

If the kidneys refuse to secrete, urine may be found in the ventricles of the brain; and, when there was no outlet for it, an urinous fluid has been furnished by the stomach, intestines, or skin, &c.[l] In the latter cases, it may be said to have been fabricated by the kidneys and discharged by the other vessels, just as the pus of an abscess has sometimes been absorbed and discharged by the kidneys[m]: still we have the singular fact of vessels allowing to stream through them a fluid totally different from that which is natural to them.

On the other hand, the circumstance of secretions being frequently performed by vessels not destined or originally employed for their production, though the blood remains the same, shows how much depends upon the power of the part itself. Fat accumulates in diseased ovaria, and even the fleshy substance of the heart may be converted into it, as I once saw in a patient of my own. Bone is every day deposited between the inner and middle tunic of the arteries, and the serous membranes, or the subserous cellular membrane, continually ossified.

The bland mucus of the urethra may, by even mechanical irritation of the canal, be converted to a fœtid puriform fluid; the yellow bile and mild intestinal fluids to green, dark, scalding bile, and fœtid discharges, under the influence of acrid cathartics. Different animals and different plants require different sorts of food and soil, — external supplies; and produce different substances by nutrition and secretion under the same circumstances.[n] So that the requisites for a given production are two — materials and organic powers; and a change in either will occasion a change in the product.

[l] See examples in Haller's *El. Physiol.* l. vii. S. i. § ix. Several such have come to my own knowledge. Mr. Howship attended a lady who, he says, discharged many quarts of urine alternately from the bladder and rectum, after intervals of several weeks of suppression; and this for four years without serious injury. *Practical Treatise on Diseases of the Urinary Organs.* 1823.

[m] See Dr. Hennen's *Military Surgery;* and perhaps Heberden's *Commentarii,* p. 408.

[n] "If wheat and peas be sown in the same water, earth, or medium, the former will uniformly deposit silex in their cuticle, and the latter none." *Introduction to Botany,* by John Lindley, F.R.S. Prof. of Botany in the University of London, p. 233.

Though many constituents of secretions are not discoverable in the blood, some curious circumstances are related to show the importance of the qualities of the blood, as well as of the secretory organs, in producing peculiar substances. It is asserted that the blood will contain bile if secretion in the liver is prevented by tying the vena portæ; and urea appears in the blood, if the kidneys are removed, so that none can be secreted.[o]

In secretion the change must be chemical. Gelatine is merely decarbonised albumen; diabetic sugar is urea deprived of azote and some of its hydrogen; and the labours of Dr. Prout are displaying the various proximate principles of animals and vegetables to have the same elements, and to differ merely in the proportion of component water, or by the presence of a minute proportion of additional substance hitherto regarded as accidentally present and unimportant. Some substances, it is true, exist in vegetables and animals that cannot at present be entirely ascribed to external sources. Dr. Prout, from most careful experiments, concluded that there is strong reason to believe that the bones of the chick are not derived from the shell, but from internal production.[p] Vauquelin found the lime of the excrements of hens, and of the shell, to be too great to be ascribed to the food[q]; and the products of plants, fixed in sand and moistened with distilled water, contain so much more carbon and earthy matter than can be supposed to enter them from the atmosphere or the water, that Dr. Bostock and others of our best chemists conceive their existence inexplicable entirely upon these sources.[r] If such is the fact, we may conclude that these substances, though classed, as air and water once were, as elements, because not yet decomposed by chemists, are really not so; for creation by natural powers is impossible.[s] But, although secretion is, I apprehend, merely a chemical process, dependent upon the quality of the blood,

[o] Prevost and Dumas found that the removal of one kidney has no particular effect; but that the removal of both occasions copious vomiting and purging of brown liquid, and death; and 5 oz. of blood yielded ℈ i. of urea. *Annales de Chimie*, tom. xxii.

[p] *Phil. Trans.* 1822.

[q] *Annales de Chimie*, tom. xxix.

[r] See Dr. Bostock, l. c. vol. ii. p. 387. sq. Braconnot concludes that earths, alkalies, metals, sulphur, phosphorus, carbon, and perhaps azote, are thus produced. The immense quantities of calcareous strata, which appear to be the remains of marine animals, are thought referable to organic production only.

[s] Dr. John ascertained that some plants convert potass into soda.—Professor Lindley, l. c.

the chemical relations of the various particles, existing quite independently of life, and perhaps aided by the length and diameter of the vessels and other mechanical circumstances, are brought into play — circumstanced so as to become efficient — by the vital powers. How, we know not. But life cannot create any more than it can annul the physical or chemical qualities of matter; nor can it create matter. It may counteract one inanimate force by opposing to it another inanimate force; it may render one inanimate force efficient by withdrawing opponent inanimate forces. But this is all; how it accomplishes this, is yet unknown.

Secretion does not depend on the mind, though, like every function, much influenced by it. Fear *increases* the production of urine, rage *dries* up the mouth; any depressing passion will *vitiate* the milk. How far it depends upon nervous influence we shall consider when speaking of the nervous system.

"There is this difference among the various fluids secreted by the organs and powers now described, — that some pass to the place of their destination immediately, while others are deposited in receptacles, and detained there for a length of time, becoming more perfect before their excretion. The milk in its ducts, the urine, bile, and semen in their respective bladders, and in some degree the serum of the vesicles of De Graaf, are examples of this."

The more watery portion is absorbed, and therefore, the longer the stay in the ducts or receptacles, the more consistent does the fluid become. If the stay is considerable, the other portions also are absorbed, as seen in the case of jaundice from obstruction of the ductus hepaticus or choledochus. The detention of the urine is not for the purpose of perfecting it, but for convenience.

CHAP. XVI.

PERSPIRATION.

THE skin is not only the organ of touch, but also, like the lungs, an organ of inhalation and excretion.

It " consists of three membranes:—The *corium*, internal; the *cuticle*, external; and the *reticulum*, intermediate.

" The *cuticle*, or epidermis [a], forms the external covering of the body, is separable into several lamellæ[b]," though it does not consist of imbricated scales[c], " and is exposed to the atmosphere, the contact of which can be borne by " no " other part, if you except" the hairs and nails, and the feathers, wool, horny hoofs, and claws of brutes, which are really of the same nature with it, and " the enamel of the teeth. For this reason, the internal cavities, and the canals which communicate with the surface for the purpose of admitting air, especially the respiratory passages and the alimentary canal," at least as far as the end of the œsophagus, " the tongue, the inside of the cheeks, the fauces, and the organ of smell, are covered by a fine epithelium, originating from the epidermis.[d]

" The texture of the epidermis is extremely simple, destitute of vessels, nerves, and true cellular membrane, and consequently" not organised; " very peculiar, however[e]; remarkably strong,

[a] " Al. Monro (PRIMUS), ORATIO *de Cuticula Humana*. Opera. English edition. Edin. 1781. 4to. p. 54. sq."

[b] " Among others, consult J. Mitchell, *Philos. Trans.*, vol. xliii. p. 111."

[c] Cloquet, *Manuel d'Anatomie descriptive*, p. 260.

[d] " Abr. Kaau, *Perspiratio dicta* Hippocrati, p. 7.

Lieberkühn, *De fabrica Villor. Intestin. Tenuium*, p. 16.

Cruikshank, *Expts. on the Insensible Perspiration*, p. 5.

Rudolphi, *Reisebemerkungen*, t. i. pp. 29. 140.

Jens. W. Neergaard, *Vergleichende Anat. der Verdauungswerkzeuge*, p. 21. et alibi.

J. B. Wilbrand, *Hautsystem in allen seinen Verzweigungen*, Giessen. 1813. 8vo."

[e] " The very dense epidermis of some immense animals consists of vertical fibres, which, in arrangement, somewhat resemble the structure of the Boletus igniarius. Its internal surface is porous, and penetrated by the silky filaments of the subjacent corium. This is remarkably exemplified in a preparation now before me, taken from the skin of the balæna mysticete.

considering its pellucidity and delicacy, so that it resists suppuration, maceration, and other modes of destruction, for a great length of time; and it is reproduced more easily than any other of the similar parts."

The cuticle separates during life by any irritant that causes a copious secretion below it; and by putrefaction after death, when the subjacent parts liquefy, and it retains its firmness. It is composed of gelatine and a cartilaginous substance like coagulated albumen, with perhaps a trace of salts of lime.

"It is" a kind of "horny lamella, and adheres to the subjacent *corium* by the intervention of a mucus, and by numerous very delicate fibrils which penetrate the latter.[f]

"The human cuticle, in certain diseased states, exhibits the same appearance as in the Englishman called the Porcupine Man, who laboured under a cutaneous complaint, which he transmitted to his children and grandchildren. Vide W. G. Tilesius, *Beschreibung und Abbildung der beiden sogenannten Stachelschwein-Menschen* (Porcupine Men). Altenb. 1802. fol.

"The innumerable polyhedrical papillæ and horny warts which I witnessed upon every part of the skin of these brothers, excepting the head, the palms of the hands, and the soles of the feet, bore some resemblance to the skin of the elephant, especially about the vertex and forehead of the animal."

One of this family exhibited himself a few years ago in Bond Street, and presented himself again lately at our schools of medicine. He was thirty years of age, and stated himself to belong to the fourth generation of the descendants of a savage who was found in the woods of America and had the same condition of skin. He informed me that it is transmitted to every male without exception in the male line, but has never appeared in the females or their male offspring: and that the horny warts first show themselves at two months from birth; are constantly growing, though most in summer; and are constantly being shed, but particularly in winter, till the thirty-sixth year, after which they are never shed, but continue to grow; so that in this man's father, who was eighty years of age, and lived in Suffolk when I saw the man, they were of very great length. They are set so close together, that their tops form a tolerably smooth surface, unless they are separated by extending the skin. Nearest those parts in which there are none, they gradually become smaller. Besides the parts mentioned by Blumenbach, the glans penis, I understood, was free from them. An arm of this family is well represented in Dr. Alibert's *Description des Maladies de la Peau.* See also *Ph. Tr.* 1731, for the first case known in the family.

"Similar, also, to the horny warts of this family are corns and the brawny cuticle of the feet in those who walk barefooted. Vide Carlisle on the Production and Nature of Corns, *Med. Facts and Observations*, vol. vii. p. 29."

[f] "W. Hunter, *Med. Observations and Inquiries*, vol. ii. p. 52. sq. tab. i. fig. 1, 2. The conjecture of this eminent man — that these fibrils are *vessels* hich excrete the perspirable matter — is, I think, improbable."

Cloquet, however, says they appear to be exhalants and absorbents. l.c. ibid.

"The pores, which Leuwenhoek imagined in it," are not visible.

"The importance of the cuticle to organised systems is demonstrated by its universality in the animal and vegetable kingdoms, and by its being distinctly observable in the embryo from the third month at latest after conception."

The purpose of the cuticle is, 1. To cover the cutis like oiled silk, and preserve it moist and fit for its functions. Were the cutis exposed to the atmosphere, it would dry, and its vessels could neither excrete nor absorb, nor its nerves feel. This is partly seen, in regard to mucous membranes, when the uterus remains prolapsed beyond the opening of the vagina.[g] The protruded membrane of the vagina then becomes pale and shrivelled, like a dried bladder. The mucous membrane of the eyes and nostrils, and of the mouth, would dry up, but for the additional moisture supplied to the former by the lachrymal glands, and to the latter by the salivary; and so would the bronchial mucous membrane, if the air did not become first charged with moisture in passing through the mouth and nostrils, and if it passed through the bronchiæ instead of entering and returning. 2. To protect the cutis, thus preserved moist, from the immediate contact of substances; some of which would be too easily absorbed, and others would produce painful sensation.

"The inner part of the cuticle is lined by a fine mucous membrane, denominated, from the opinion of its discoverer, *reticulum Malpighianum,* and by means of which chiefly the cuticle is united more firmly to the corium.[h]

"Its nature is mucous; it is very soluble; and, being thicker in Ethiopians, may be completely separated in them from both the corium and cuticle, and made to appear as a true distinct membrane."[i]

[g] Skin and mucous membranes have much relation to each other; and by constant dryness of the latter, and constant moisture and excitement of the former, a great approximation may be effected.

[h] "Hence I have found the epidermis of *Albinoes* separate easily by the heat of the sun; whereas, in negroes, it scarcely does so on the application of a blister Consult Mitchell, l. c. p. 108."

[i] "B. S. Albinus, *De sede et causa coloris Æthiopum et cæteror. hominum.* Lugd. Batav. 1737. 4to. fig. 1.

Sam. Th. Soemmerring, *über die körperl. Verschiedenh. des Negers vom Europäer.* Ed. 2. p. 46. sq.

Some even of the moderns have assigned many laminæ, and even different

Dr. Gordon[k] and Mr. Lawrence[l] assert that they have never been able to detach any thing from the cutis of Europeans in the form of a distinct membrane; but the rete Malpighianum does exist in negroes, and the latter gentleman allows that the various complexions of Europeans and the peculiar cream white of the Albino, who has unquestionably no colouring matter in his eyes or skin, show that the substance exists even in us. Indeed, M. Gaultier considers that it has actually four layers: 1. An internal, composed of blood vessels; 2. One above this, of a white colour; 3. Another, composed of minute granules, which are brown in negroes and white in Europeans; and, 4. An external, also white, like the second. Some say that the black matter, as seen in negroes, when washed out, leaves a membrane and subsides to the bottom of the water, as a powder, and that it resembles the pigmentum of the eye and the matter of melanosis.

" Our colour resides in it. In all persons the corium is white, and, in almost all, the cuticle white and semipellucid, though in Ethiopians it inclines to grey. But the mucous reticulum varies after birth, with age, mode of life, and especially with difference of climate.

" Thus among the five varieties into which I would divide the human race, in the first, which may be termed Caucasian, and embraces Europeans (except the Laplanders and the rest of the Finnish race), the western Asiatics, and the northern Africans, it is more or less *white*.

" In the second or Mongolian, including the rest of the Asiatics (except the Malays of the peninsula beyond the Ganges), the Finnish races of the north of Europe, as the Laplanders, &c. and the tribes of Esquimaux widely diffused over the most northern parts of America, it is *yellow* or *resembling box-wood.*

" In the third or Ethiopian, to which the remainder of the Africans[m] belong, it is of a *tawny* or *jet black.*

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species, to the reticulum; as Lieutaud, *Essais Anatomiques,* p. 103. edition 1766.

Cruikshank, l. c. pp. 43. 99.

But especially G. A. Gualtier, *Recherches Anatomiques sur le Système cutané de l'Homme.* Paris, 1811. 4to."

[k] *System of Anatomy,* vol. i. p. 242.

[l] Rees's *Cyclopædia,* art. Integuments.

[m] " Jo. Nic. Pechlin, *De Habitu et Colore Æthiopum, qui vulgo et Nigritæ.* Kilon. 1677. 8vo.

Camper's oration on the same subject will be found in his *Kleiner Schriften,* vol. i. P. i. pp. 24—49."

"In the fourth or American, comprehending all the Americans excepting the Esquimaux, it is almost *copper coloured*, and in some of a *cinnamon*, and, as it were, *ferruginous*, hue.

"In the fifth or Malaic, in which I include the inhabitants of all the islands of the Pacific Ocean, and of the Philippine and Sunda, and those of the peninsula of Malaya, it is more or less brown, — between the hue of fresh mahogany and that of cloves or chestnuts.

"All these shades of colour, as well as the other characteristics of nations and individuals, run so insensibly into one another, that all division and classification of them must be more or less arbitrary.

"The essential cause of the colour of the Malpighian mucus is, if we mistake not, the proportion of carbon which is excreted together with hydrogen from the corium, and which, in dark nations, being very copious, is precipitated upon the mucus, and combined with it. [n]

"The *corium*, which is covered by the reticulum and epidermis, is a membrane investing the whole body, and defining its surface; tough; very extensible"; thicker on the posterior part of the trunk and neck than the anterior, and on the outside than the inside of the extremities; of a fibro-cellular texture; consisting almost entirely of gelatine; "every where closely compacted, and, as it were, interwoven, especially externally, but more loosely at its internal surface, in which, excepting in a few regions of the body, we generally discover fat." On the outer surface of the corium, we observe innumerable, very minute, soft, erectile papillæ, supplied with vessels and nerves. They are far most distinct in the soft part of the ends of the fingers and toes, and upon the palms and soles, and scarcely distinguishable in other parts where the corium is thinner.

"Besides *nerves* and *absorbents*, of which we shall speak here-

[n] "I have given this opinion at some length, in my work, *De Gen. Human. Varietate Nativa*, p. 122. sq. ed. 3. Some eminent chemists accord with me, among whom suffice it to mention the celebrated Humphry Davy, *Journals of the Royal Institution*, vol. ii. p. 30. '*In the rete mucosum of the African, the carbon becomes the predominant principle; hence the blackness of the negro.*' W. B. Johnson, l. c. vol. ii. p. 229.

F. B. Osiander has given an abundance of very careful observations upon the various proportions of the carbonaceous element in the Malpighian mucus. *Comment. Soc. Reg. Scientiar. Gotting. recentiorum*, vol. iv. p. 112. sqq."

after, innumerable blood-vessels penetrate to its external surface, upon which they are shown, by minute injection, to form very close and delicate networks.

"A vast number of *sebaceous follicles*," or bags with a single opening in their upper part and minute ramifications of blood-vessels on their interior, "also are dispersed throughout it" except the palms and soles, "and diffuse over the skin an oil, which is [o] very thin, limpid, does not easily dry, [p]" keeps the cuticle in a pliable state, and preserves it from any excessive operation of moisture, "is altogether distinct from the common sweat, and does not possess any odour" except in certain parts.

"Lastly, almost every part of the corium is beset with various kinds of *hairs* [q], chiefly short and delicate, more or less downy, and found nearly every where but on the palpebræ, penis, the palms of the hands, and soles of the feet. In some parts, they are long and destined for peculiar purposes; such are the capillamentum, the eye-brows, the eye-lashes, the vibrissæ, mustachios, beard, and the hair of the armpits and pudenda.

"Man is, generally speaking, less hairy than most other mammalia. But in this respect nations differ; for, not to mention those nations who to this day carefully pluck out their beard or the hair of other parts, others appear naturally destitute of hair, *v. c.* the Tunguses and Burats. [r] On the contrary, very

[o] "Chr. Gottl. Ludwig, *De Humore cutem inungente.* Lips. 1748. 4to."

[p] "Lyonet, *Lettre à M. Le Cat,* p. 12."

[q] "J. Ph. Withoff, *De pilo Humano.* Duisb. 1750. 4to. Compare the *Commentar. Societ. Scient. Gotting.* vol. ii.

Job. Baster, *Verhandel. der Maatsch. te Haarlem,* t. xiv. p. 382.

C. Asm. Rudolphi, *De pilorum structura.* Gryph. 1806. 4to."

[r] Dr. Wells describes the singular case of a man whose hair fell off throughout his body in about six weeks, without any evident cause or derangement of health, and did not return, except that about two years afterwards, while labouring under a suppurating tumour of the neck that discharged through several small holes, a fine down appeared upon his cheeks and chin, which occasioned him to shave once a week for about three months, when it disappeared. He always looked afterwards as if just shaved, and by wearing a wig would not have been noticed for any peculiar appearance. (*Transactions of a Society for the Improvement of Medical and Surgical Knowledge,* vol. ii.) Dr. P. Frank saw a similar case. (*De curandis hominum morbis,* t. iv. p. 124.) Another case will be found in the *Edinburgh Journal of Medical Science,* 1827. Morgagni mentions a man who had no hairs, except a few at the root of the penis, and yet whose genitals were well developed (*De Sedib. et Causis Morb.*, l. iii. Ep. 46.); Heister, a man who lost his hair without any obvious cause for ten years. Consult Dr. Otto's *Compend.*

credible travellers assert that some inhabitants of the Kurille and other islands in the Pacific and Indian Ocean are remarkably hairy." [s] But Krusenstern, a late circumnavigator, declares that he observed no particular hairiness of the people in this part of the world, and that former accounts are at least exaggerations.[t] In the island of Anicoa, he indeed met with one child, eight years of age, covered with hair; but such an instance has occurred in Europe. Zacchias, in 1613, saw a tall man at Rome covered with fine, long, straight hair, of a light yellow colour. There was a sister similarly hairy, and the father had been a hairy person, but the mother had not differed from other women. The man married; and, of four children, one girl and one boy were born covered with black hair, looking, says Zacchias, like black kids, and reminding the attendants of the account of Esau's birth: — "The first came out red, all over like a hairy garment." [u] In fifteen days the whole of this hair fell off; and, as puberty approached, soft fine hair sprung up all over the body, even over the temples and forehead. [x] Shenckius has collected several similar cases. [y]

Evelyn says, "On the 15th of August, 1657, I saw the hairy woman, 20 years old, whom I had before seen when a child. She was borne at Augsburg, in Germany. Her very eyebrowes were comb'd upwards, and all her forehead as thick and even as growes on any woman's head, neatly dress'd; a very long lock of haire out of each eare; she had also a most prolix beard, and mustachios, with long locks growing on the middle of her nose, like an Iceland dog exactly, the colour of a bright browne, fine as well-dress'd flax. She was now married, and told me she had one child

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of Path. Anat., translated by Mr. South, with additions, 8vo, Lond. 1831; where will be found abundant references to cases of most curious singularities of all the common integuments. Inflammation of the skin will make the hair fall off; as well as dirt, fever, pain of the head, the administration of mercury, and other causes of debility. They generally grow again, when the health is renovated, whether recourse is had to shaving or not.

[s] "*De Generis Human. Variet. Nativ.*, p. 29."

[t] *Voyage round the World.* Translated from the original German by G. B. Hoppner, vol. ii. p. 78.

[u] *Genesis*, c. xxv.

[x] *Quæstiones Medico-Legales*, lib. vii. Tit. 1. quæst. ix.

[y] Παρατηρήσιων, sive *Observ. &c. Volumen*, p. 778. sq.

that was not hairy, nor were any of her parents or relations. She was very well shap'd, and plaied well on the harpsichord," &c.[z]

"Nor is there less variety in the length, flexibility, colour, and disposition to curl, of the hair, both in each race of men enumerated above, and in individuals: *v. c.* the hair of the head in the Caucasian variety is rather dingy or of a nut brown, inclined on the one hand to yellow, and on the other to black; in the Mongolian and American, it is black, stiffer, straight and more sparing; in the Malay, black, soft, curling, thick, and abundant; in the Ethiopian, black and woolly: in individuals, especially of the Caucasian variety, there are great differences, and chiefly in connection with *temperament*, which is found intimately and invariably connected with the colour, abundance, disposition to curl, &c. of the hair[a]; and there also exists a remarkable correspondence between the colour of the hair and of the irides.

"The direction of the hairs is peculiar in certain parts, *v. c.* spiral on the summit of the head; diverging upwards on the pubes; on the exterior of the arm, as is commonly seen in some anthropomorphous apes (*v. c.* in the satyrus and troglodytes), running in two opposite directions towards the elbow, *i. e.* downwards from the shoulder, upwards from the wrist; to say nothing of the eye-lashes and eye-brows."

A hair consists of a bulb[b] and stem. The bulb or follicle, again, is ovoid, traverses the cutis obliquely, and consists of a capsular membrane, white, firm, and continuous at its outer extremity with the cutis, and of another internal, reddish, soft, delicate, and continuous with the rete mucosum. The cavity of the follicle is chiefly filled with a bud or conical papilla, adherent at its base to the bottom of the cavity, and free at its summit towards the

[z] Bray's *Memoirs of Evelyn*, vol. i. p. 307. 4to. 1819. In Granger's *Biography* an engraving and a mezzotinto of her are described. There is a curious engraving of her in the *Ephem. Nat. Curios.*, v. ii. obs. xcv. Her name was Barbara Van Beck.

[a] "Galen, *Ars Medicinalis*, pp. 211—235. M. Ant. Ulm, *Uterus Muliebris*, p. 128. et alibi, and Lavater, *Fragmente*, t. iv. p. 112., among many others."

[b] "I suspect that the bulb is intended for support rather than for nourishment, from this circumstance — that the locks of hairs sometimes found in melicera and steatomata of the omentum and ovarium, some of which I have now before me, are usually destitute of bulbs, because they are not fixed, but lie naked in the honey-like fatty matter."

orifice of the follicle. On the exterior of the base of the follicles, filaments like roots are seen, and nerves and blood-vessels may be traced into it.

The stem is conoid, and proceeds from the interior of the bulb. Its base is hollow, and embraces the papilla; very soft, and even fluid where it is in contact with the papilla, which appears to secrete it. The rest is a horny, transparent, almost colourless sheath, and an internal coloured texture, consisting of very delicate filaments, and in some animals of an areolated texture.

The cuticle just enters the bulb, and is reflected and lost upon the surface of the stem. [c]

" The hairs are almost incorruptible, and always anointed by an oily halitus. Of all parts they appear most truly electrical. They are very easily nourished and even reproduced, unless where the skin is diseased."

They have been represented destitute of life. But they have turned permanently white in a single night from excessive copulation, and from fear and distress of mind.[d] In illness they often grow soft, and hang about the head. I know a lady whose hair will not keep in curl if she is in the slightest degree indisposed, and a young gentleman whose profuse curly hair becomes straight under the same circumstances: on the other hand, a case is recorded in which it always curled in a fit of the gout.[e] Hair taken from a dead body is said to be unfit for artificial use; it must be taken from the living: just as intestines taken from animals, not even diseased, but merely driven from a distance to the London markets, are said to be unfit for the strings of musical instruments. Shells are also considered destitute of life; but they cannot be rendered beautiful, I am told, if the fish dies of disease, or putrefies in them. Lastly, the hair has been so sensible in phrenitis after an injury, that the slightest touch gave severe pain; and when the surgeon clipped a hair unseen by the patient, this

[c] Cloquet, l. c.

[d] " My hair is grey, but not with years,
Nor grew it white in a single night,
As men's have grown from sudden fears."

Prisoner of Chillon.

See Byron's note to these lines, and Dr. Speranza in Dr. Omedei's *Annali Universali di Medicina.* Feb. 1832. Milan.

[e] *Quarterly Journal of Foreign Medicine,* No. xvii.

was instantly felt, and occasioned a paroxysm of rage.[f] Now sensibility cannot be acquired by a part not already alive.

Hair often grows abundantly in portions of the skin usually not much supplied with it, and these are generally of a brown colour: it will sometimes grow in parts naturally destitute of it, as the tongue and even the heart.[g] Sometimes it grows in encysted tumours, accompanied by fat, and occasionally by teeth and portions of jaw and amorphous bone; and feathers covered by fat are sometimes found in the thorax and abdomen of tame geese and ducks.[h] Hair has also been discharged from the urethra.[i] It has many times been seen blue as well as green.[k]

The skin produces *chemical changes* similar to those which occur in the lungs[l], and, like them, forms a watery *secretion*

[f] l. c. ibid.

[g] See references in Dr. Good's *Study of Medicine*, (4th edit.) vol. iv. p. 525.

[h] Blumenbach, *Comparative Anatomy*, § 138.

[i] *Phil. Trans.* abridg. vol. v. and ix.

[k] Various instances of both kinds in man and horse are collected by Dr. Speranza, l. c. Horses have had curly hair. Otto, l. c.

[l] " W. Bache, *On the Morbid Effects of Carbonic Acid Gas on Healthy Animals.* Philadel. 1794. 8vo. p. 46. Abernethy, l. c." Cruikshanks on *Insensible Perspiration*, and Ellis, *Further Inquiry on the Changes produced in Atmospheric Air*, &c. Others have questioned this, but no one doubts the fact in regard to cold-blooded animals. Dr. Edwards found the surface of frogs and salamanders to carbonise the air (l. c. p. 12.). Frogs are amphibious. They live indefinitely in extensive or renewed water, and die if it is de-aërated, or not changed (p. 41. sqq.); as also do aquatic salamanders and the common toad. If their lungs are removed, they still live indefinitely in such water or in air, and die if no air has access to their skin, or the water is not purified enough (p. 71.); and die sooner as they are younger and smaller. Although frogs live in air, mere respiration appears insufficient after a time; — some application of air or aërated water to the surface is also requisite to their life. That they live so long inclosed in wood or mineral substances, as is commonly known, appears owing to the opposition afforded, under these circumstances, to transpiration, which, in the open air, is so great as speedily to dry them up, while, at the same time, the closeness is not such as to entirely exclude air (p. 13.). They die in vacuo.

In a limited quantity of water, they die sooner the higher the temperature (p. 25. sqq.); and they support a high temperature better, if previously subjected for some time to a cold temperature (p. 33. sqq.). Although their skin be carefully moistened, they cannot live without respiration in summer (p. 91.). It appears from Dr. Edwards's experiments to be a general fact among animals, that the want of air is best borne in a low temperature. The general good effect of the application of cold in asphyxia by carbonic acid, is well known. The greater the external heat, on the contrary, the more is air required by the skin and

and excretes foreign matters, and is an organ of *absorption.*

The watery secretion is sometimes termed *perspirabile Sanctorianum*[m], after the patient and acute philosopher who first applied himself professedly to investigate its importance.

To ascertain the quantity of watery *secretion*, Lavoisier and Seguin[n] enclosed the body in a silk bag varnished with elastic gum and having a small opening carefully cemented around the mouth, so that, by weighing the body previously and subsequently to the experiment, they were able to ascertain exactly what had been lost, and, by subtracting from this loss the weight of the perspired contents of the bag, they also ascertained how much of this had passed off by the lungs. From repeated trials they found the mean pulmonary discharge in twenty-four hours amounted to

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lungs, independently, it would appear, of its chemical effect, as it is of use when there is no circulation, — when the heart is excised, either in frogs or cats, which perish after this operation the sooner as the temperature is higher. When the quantity of water, though limited, is sufficient to support life, the want of respiration causes the frogs to become as slow in their motions as turtles, and dull to all impressions on the senses (p. 65.). Lizards, serpents, and turtles, also carbonise the air by their surface; but serpents and turtles, and, indeed, some varieties of frogs, can live by respiration only, and this happens where the lungs of the animal are proportionally large (p. 128.). The effect of air, however, upon the surface, in reptiles at least, does not require the aid of circulation to distribute its benefits; for, when their heart is removed (and the same happens with toads, salamanders, and cats), they live much longer in air than in de-aërated water (p. 3. sqq.); yet they live longer if the heart is not removed (p. 7. sqq.).

[m] " *Ars* Sanctor. Sanctorii *de Statica Medicina aphorismor. sectionibus vii. comprehensa.* Venet. 1634. 16mo.

C. de Milly and Lavoisier, *Mémoires de l'Acad. des Sc. de Paris.* 1777. p. 221. sq. 360. sq.

J. Ingen-Housz, *Expts. upon Vegetables.* Lond. 1779. 8vo. p. 132. sqq.

J. H. Voight. *Versuch einer neuen Theorie des Feuers,* p. 157. sq."

" The balance employed by Sanctorius to estimate the loss of perspired matter is described in his *Comm. in* primam *Fen* primi *L. Canon.* Avicennæ. Venet. 1646. 4to. p. 781.

Another, much simpler and better adapted for the purpose, is described by Jo. Andr. Segner, *De Libra, qua sui quisque corporis pondus explorare posset.* Gotting. 1740. 4to.

J. A. Klindworth, an excellent Gottingen instrument-maker and engineer, altered this at my suggestion, and rendered it more convenient and accurate."

[n] *Mémoires de l'Academie des Sciences,* 1790.

15 oz., and the cutaneous to 30 oz. The quantity of carbon separated by the lungs ought however to be taken into the account. If it amount to 11 oz. in twenty-four hours,—the quantity stated by Allen and Pepys—there will be but 4 oz. of pulmonary exhalation. But if oxygen and azote are absorbed in respiration, there must have been correspondently more pulmonary exhalation; and we have seen that Hales estimated it at about 20 oz. in the twenty-four hours. They found the cutaneous transpiration at its minimum during and immediately after meals, and at its maximum during digestion.

The minimum after digestion was found by them to be 11 grs. per minute; the maximum 32 grs.: at and immediately after dinner $10\frac{2}{10}$; and the maximum $19\frac{1}{10}$, under the most favourable and unfavourable circumstances. It was increased by liquid, but not by solid, food. The pulmonary they regard as greater than the cutaneous, proportionally to the surface on which it occurs.[o] Whatever was taken, the weight was found to become ultimately as before. Indigestion lessened transpiration, and the body continued heavier generally till the fifth day, when the original weight was restored. Transpiration was less in moist air and at a low temperature, and the pulmonary and cutaneous transpirations obeyed the same laws.

Dr. Edwards has made a great number of experiments upon this subject.[p] He distinguishes the loss of fluid by evaporation of what is exuded, from that by secretion.[q] The former occurs even in the dead body, and is increased in both the dead and living, and among all animals, by the dryness, motion, and diminished pressure of the atmosphere. It may be suspended by saturating the air with moisture, and by employing animals (vertebrated, cold-blooded) whose temperature is not above that of the atmosphere; for, if those are employed whose temperature exceeds that of the atmosphere, the air as soon as it touches them is rarified, can take up more moisture, and is no longer air saturated with moisture. These circumstances, of course, affect only the removal or evaporation of fluid which may have either transuded or been secreted, but do not affect the secretion. In frogs,

[o] *Annales de Chimie,* t. xc.

[p] l. c. part iv. c. xi.

[q] He contends, however, that, in the lungs, all is evaporation without secretion. But, with Dr. Bostock, I must dissent from him.

which perspire copiously, the loss by evaporation at 68° is thus found six times greater than by mere secretion, and the proportion in man, the temperature being the same and the air dry, must be greater, as his skin secretes much less.

The secreted fluid may be carried off by evaporation as quickly as it is formed, so as to be insensible perspiration; or may be too abundant for this, and appear as sweat. The transuded fluid may also be condensed and precipitated on the skin in the form of sweat.

The cutaneous secretion is not so much augmented by moderate elevations of temperature as might be imagined; but, as the elevation proceeds, the augmentation of secretion becomes more than proportionate. It appeared increased after meals and during sleep, and, though subject to great fluctuations, if observed at short intervals, from accidental changes in the atmosphere, underwent successive diminutions when observed every six hours, from six o'clock A. M. — the hour of rising — till the return of the same period. In frogs this regular diminution might be detected every three hours.[r]

In frogs the cutaneous secretion continues, though at its minimum, in the moistest air and in water; and it would appear to do so also in man.[s]

The matter of the cutaneous secretion contains an acid, probably the acetic, chloride of potassium and sodium, acetate of soda, and perhaps albumen.[t] What evaporates is mere water.

Dr. Edwards makes some curious remarks upon the different effects of dry and moist air, when hot, and when cold. When hot, dry air will of course communicate less heat to the body than if moist, and will, by its dryness, cause more evaporation; and thus carry off more heat; so that the two operations of air, dry or moist, will correspond in temperatures above that of the body. When cold, dry air will remove less heat from the body than moist; but, by its dryness, will cause more evaporation, and therefore tend to cool more, so that the two operations oppose each other in temperatures inferior to that of the body.[u] The same remarks apply to cold water.

[r] For what relates to this function in the batrachians, see l. c. part i. c. v. and vi.

[s] p. 92. sqq. 98. sqq. 351. sqq.

[t] Berzelius, *Animal Chemistry*, p. 95.

[u] l. c. p. 386. sq.

He did not find moist cold air to cool animals more than dry cold air.

In low temperatures, we have seen that the loss by evaporation greatly exceeds that by secretion. In high, it is the reverse; and, when the body is covered with sweat, there can be no loss by the evaporation which occurs, independent of secreted fluid, whether the air be dry or moist. Vapour will cause more loss by secretion than dry air; but no loss can take place by the lungs in hot vapour.[x]

Perspiration can never be entirely suppressed; because the cold which suppresses secretion, causes the air, however moist, and therefore opposed to evaporation, to rise in temperature, by coming in contact with the body; and the superior temperature which it instantly acquires, enables it to hold more moisture, and evaporation from the skin is thus instantly promoted.[y]

There is a common belief, that the cutaneous exhalation has always peculiar properties, invigorating in the young, and debilitating in the old. David lay between two young girls to gain strength; and Dr. Copland declares he has seen a child suffer from lying with its grandmother.[z]

The elimination of foreign matters by the skin is shewn by the odour of the perspiration after some odorous substances have been taken, by its effect upon silver when mercury is prescribed, and by its green and coppery secretion when copper has been introduced.[a]

The odour of the secretion of the sebaceous follicles, and that of the perspiration, are, in some parts, naturally peculiar, and in different persons more or less intense, and even singular; and either always, only under excitement, or only at times when under excitement, in different parts. In the tonsils,

[x] p. 380. sq. [y] p. 335. sq.

[z] *Dictionary of Practical Medicine*, by James Copland, M.D., art. Debility. A work displaying such extraordinary extent of reading, and such deep and comprehensive reflection, as to demand a place in the library of every medical man.

[a] See a case in the *Lond. Med. Gazette*, Nov. 19. 1832.

"Hence the danger of contagion from hairs, as miasmata adhere to them very tenaciously for a great length of time. Vide Cartwright, *Journal of Transactions on the Coast of Labrador*, vol. i. p. 273. vol. ii. p. 424."

"G. Wedemeyer, *Historia Pathologica Pilorum* (honoured with the royal prize). Gotting. 1812. 4to."

when the secretion is solid, it is horridly offensive, really fæcal, and is a frequent cause of fœtid breath: in the glands behind the ears, when the secretion is squeezed out in a solid form, its smell is said to be caseous: in the parts of generation, saline and peculiar. In many brutes, the odour of the female genitals attracts the male, and is strongest when the animal is in heat. All know that the mere sweat has a different smell in different parts; in the arm-pits, hircine; in the feet, sometimes like that of tan, and sometimes of cabbage-water. If the palms of the hands of some persons are rubbed briskly together, an odour something like that of hot boiled potatoes is evolved; in others general excitement of the system occasions this. A sulphureous odour, which perhaps was not very dissimilar, is said, in the *Ephemerides*, to have proceeded from Cardan's arm; from the head of a boy at Rome; and from a dropsical boy.[b] Schmidt mentions a man from whose hands and arms an intolerable fœtor of sulphur proceeded.[c] Egesandro mentions two persons so offensive that they were not allowed to visit the public baths.[d] In the same volume of the *Ephemerides* we read of a literary man whose stench was far too much for all perfumes; and Hagendorn declares he saw a woman who was unbearable at the distance of some feet, — a second Thais.[e] In America the shrew spreads a horrid stench to escape its pursuers; and the yellow serpent of Martinique is known by its fœtor to be present. Persons differ not only in the amount of their general perspiration, but in its amount in different parts; and under exercise and heat different

[b] *Ephem. Nat. Curios.* ann. ii. p. 191.

[c] *Ephem.*, ann. viii. Dec. 2.

[d] *Giornale Venet.* t. ii. See Dr. Speranza, l. c. p. 241.

[e] Tam male Thais olet, quam non fullonis avari
Testa vetus, media sed modo fracta via;
Non ab amore recens hircus; non ora leonis;
Non detracta cani Transtiberina cutis;
Pullus abortivo nec quum putrescat in ovo:
Amphora corrupto nec vitiata garo.
Virus ut hoc alio fallax permutat odore
Deposita quoties balnea veste petit;
Psilothro viret, aut acida latet oblita creta:
Aut tegitur pingui terque quaterque faba.
Quum bene se tutam per fraudes mille putes?
Omnia quum fecit, Thaida Thais olet.

MART. l. vi. ep. 93.

persons sweat most in different parts. Now a person, from merely happening to sweat most in a part, the secretion of which is generally offensive, may probably acquire the characteristic odour, without having a particular disposition to filthiness of secretion. The general perspiration of every one probably smells peculiarly, for savages can distinguish the nation of persons by the smell.[e] (Haller and Humboldt.) The boy born deaf and blind, whose history is related by Mr. Dugald Stewart, distinguished people by their odour; and I once saw, in the report of a trial in the newspapers, that dealers in hair boasted of being able to tell the nation from which the hair came, merely by the smell. The power possessed by brutes in distinguishing and tracing us and other animals is well known; and we perceive the various odours of many brutes, especially if they perspire freely and are numerous. The odour of a dog-kennel on the one hand, and of a heated flock of sheep in the road, must be known to every one. No doubt every animal and vegetable, like all inanimate matter, exhales a peculiar odour, cognisable to organs which are of sufficient acuteness and not blunted by habitual exposure to it.

In different diseases the odour of the perspiration is often peculiar; and the admission of certain substances into the system, that escape by the pulmonary and cutaneous secretions, will necessarily give them an odour.[f] Some odours of animals are most intense during sexual heat.

The odour of some persons is said to have been quite a perfume. Plutarch mentions that Alexander the Great smelt, not of carnage like a hero, but most pleasantly. Fragrance proceeded also from Augustus.[g] In the memoirs of the Queen of Navarre we read that Catherine de' Medici was a nosegay; and Cujacius

[e] "Fr. L. Andr. Koeler, *De Odore per cutem spirante in statu sano ac morboso.* Gotting. 1794. 4to."

[f] ——— Elevés dans Paris,
Sentent encore le chou dont ils furent nourris.

MOLIÈRE.

[g] Since both these were worshipped as gods we cannot wonder at the thing; for the most elegant of the gods and goddesses had all this attribute. Diana was recognised by Hippolytus from her divine odour,

—— Ὦ θεῖον ὀδμῆς πνεῦμα —

. . . . .

Ἐστ' ἐν δόμοισι τοῖσδέ γ' Ἄρτεμις θεά;

EURIPIDES, *Hippolytus*, 1391.

the civilian, and Lord Herbert of Cherbury, were equally delightful. Dr. Speranza lately witnessed a strong balsamic fragrance from the inner part of the left forearm of a healthy man, which continued, especially in the morning, for two months, and ceased for good on the supervention of fever.[i] Van Swieten mentions a man whose left armpit smelt strongly of musk; and Wedel and Gahrliess saw each a similar example.[k]

Absorption by the skin, unless friction is employed or the cuticle abraded, has been denied. We are told that Dr. Currie's patient, labouring under dysphagia seated in the œsophagus, always found his thirst relieved by bathing, but never acquired the least additional weight[l]: that Dr. Gerard's diabetic patient weighed no more after cold or warm bathing than previously[m]: that Seguin found no mercurial effects from bathing a person in a mercurial solution, provided the cuticle remained entire; while they occurred when the cuticle was abraded.[n]

But the two former cases are no proofs that water was not absorbed, because the persons immersed did not lose in weight, which they would have done if not immersed, owing to the pulmonary and cutaneous excretions; these therefore must have been counterbalanced by absorption somewhere, and no shadow of proof can be urged against its occurrence by the skin, as Dr. Kellie remarks in his excellent paper on the functions of this part.[o] Seguin besides found two grains of the mercurial salt disappear in an hour from the solution when of the temperature of 72½°.

There is every reason to believe the occurrence of cutaneous absorption independently of friction or abrasion of the cuticle. First, the existence of absorbents all over the surface cannot be intended for use merely when friction is employed or the cuticle

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When Venus showed herself to her son,

Ambrosiæque comæ divinum vertice odorem
Spiravere. *Æneid.* i. 403.

Homer says the same of Venus (*Odyss.* θ), and of Juno (*Iliad*, ξ. 170. sqq.). Flora, Ceres, and Apollo also were nosegays.— Ovid, *Fast.* v.; Homer, *Hymn. in Cererem.*

[i] *Annali universali di Medicina*, Feb. 1832.

[k] *Ib.* Where three other cases of fragrance are referred to, in two of which it proceeded from the hands; as well as singular examples from among brutes.

[l] *Medical Reports, &c.*

[m] Rollo, *On Diabetes.*

[n] *La Médecine éclairée, &c.* t. 3.

[o] *Edinburgh Med. and Surg. Journal*, vol. i.

abraded. So numerous are its absorbents, that, when successfully injected with mercury, the whole surface looks like a sheet of silver.[p] Secondly, we have many facts which prove absorption without these circumstances, either by the skin or lungs, or both, while no reason can be given why they should be attributed solely to the lungs. A boy at Newmarket, who had been greatly reduced before a race, was found to have gained 30 oz. in weight during an hour, in which time he had only half a glass of wine.[q] Dr. Home, after being fatigued and going to bed supperless, gained 2 oz. in weight before seven in the morning.[q] In three diabetic patients of Dr. Bardsley's, the amount of the urine exceeded that of the ingesta, and the body even increased in weight, and in one of the instances as much as 17 lbs.[r] Dr. Currie allows that, in his patient, "The egesta exceeded the ingesta in a proportion much greater than the waste of his body will explain; and, indeed, such facts occur every day." The same patient's urine, too, after the daily use of the bath, flowed more abundantly and became less pungent. Keill says that he one night gained 18 oz. in his sleep: and Lining, that, after drinking some punch one cool day, "the quantity of humid particles attracted by his skin exceeded the quantity perspired in these two hours and a half by $8\frac{1}{3}$ oz.," and gives two more such instances in the same table.[s] Dr. Edwards observed similar facts in guinea-pigs. Thirdly,[t] we have positive evidence of cutaneous absorption without friction or abrasion, in the case of frogs, toads, nay, in scaly lizards, which will increase in weight by cutaneous absorption, even if only a part of them is immersed in water; and remarkably so if previously made to lose much of their moisture by exposure to the air[u], although they never surpass the point from which the loss of weight began.[v] The increase is much greater in water than in the moistest air.[x] Dr. Beaupré says, that, if a new born puppy is held a quarter of an hour in warm ink, the urine subsequently made is coloured.[y]

[p] Dr. Gordon, *Anatomy*, p. 234.

[q] Bishop Watson, *Chemical Essays*, vol. iii. p. 101.

[r] *Medical Facts and Experiments.*

[s] *Phil. Trans.* vol. xlii. p. 496.

[t] l. c. p. 362.

[u] Dr. Edwards, l. c. part iv. ch. xii.

[v] l. c. p. 101.

[x] l. c. p. 360.

[y] *A Treatise on the Effects and Properties of Cold*, by M. Beaupré, M.D., translated, with notes, by Dr. Clendinning. Edin. 1826. p. 56.

In all the cases which have been mentioned, there is no reason to suppose that exhalation did not continue, both on the skin and in the lungs, so that the absorption must have been greater than it at first sight appears. When no increase of weight has taken place on immersion in the warm bath, absorption must have occurred to maintain the weight, notwithstanding the cutaneous and pulmonary losses; and, when some decrease of weight has been observed, we are not justified in concluding that absorption had not taken place and not lessened the amount of the loss which would have happened. Indeed, there is no doubt that perspiration is considerably increased in the warm bath. — I may remark that, while absorption is more active accordingly as more fluid has been lost, it gradually becomes less as it approaches the habitual standard of plenitude in the individual, and that, while transpiration is increased by elevation, the proportion of absorption is increased by depression of temperature. [z]

Dr. Massy, of America, about 1812, found that, if the body were immersed in a decoction of madder, this substance became discoverable in the urine by the alkalies; and Dr. Rousseau, in conjunction with Dr. S. B. Smith, made, in consequence, a number of experiments, from which they conclude that rhubarb and madder are so absorbed, and that these only of all absorbed substances can be discovered in the urine, and are seen in this fluid only, and are absorbed by no other parts than the spaces between the middle of the thigh and hip, and between the middle of the arm and shoulder. [a]

[z] l. c. p. 98. sqq. 352. sqq.

[a] *Discourses on the Elements of Therapeutics and Mat. Med.* 1817. vol. i. p. 56. sq.

Vegetables perspire copiously during the day; not so much according to the temperature, but to the intensity of light; and De Candolle found that lamps had a similar power on the function to that of the solar ray, and proportionately to their intensity. (*Physiologie Végétale*, t. i. p. 112.) The number of pores or stomata through which the fluid exhales, will also influence its quantity. Hales inferred that a sunflower, three feet high, exhaled only twenty ounces, — seventeen times more, according to him, than would have been perspired from an equal extent of

the human surface. Generally the sap loses about two thirds of its water, and the exhaled portion is probably pure, or does not contain more than a 10,000,000th part of the foreign matter which it had when first absorbed. (Dr. Roget, *Bridgewater Treatise*, vol. ii. p. 27. sq.)

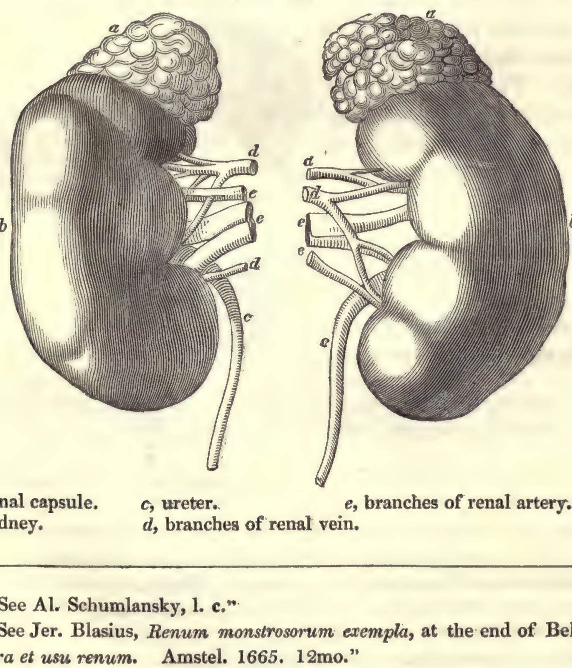
The greater number of cellular plants absorb water equally at every part of their surface. Lichens only in particular parts. In vesicular plants the surface absorbs but little, except when the roots have been removed, or can obtain no water.

CHAP. XVII.

THE URINE.

There is another fluid incessantly secreted, and always discharged from the body, that serves no direct purpose, like the bile or saliva, — is not *recrementitious;* nor indirect purpose, like the perspiration, which regulates our temperature and preserves the skin in a fit and healthy state; but is purely *excrementitious.* It is the *urine,* and is produced by the kidneys.

" The kidneys [a] are two viscera, situated at the upper part of the loins on each side, behind the peritonæum; rather flattened; more liable than any other organ to varieties of figure and number [b];" connected with the aorta and vena cava inferior by the



a, renal capsule. *c*, ureter. *e*, branches of renal artery.
b, kidney. *d*, branches of renal vein.

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[a] " See Al. Schumlansky, l. c."

[b] " See Jer. Blasius, *Renum monstrosorum exempla*, at the end of Bellini, *de structura et usu renum.* Amstel. 1665. 12mo."

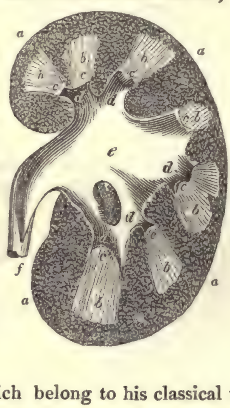
renal artery and vein[c], "which are excessively large in proportion to them; and imbedded in sebaceous fat.

"They are enveloped in a membrane of their own, which is beautifully vascular; and each, especially during infancy, consists of eight, or rather more, smaller kidneys, each of which again consists, as Ferrein asserted, of seventy or eighty fleshy radii, denominated by him pyramides albidæ.

"A kidney, if divided horizontally, presents two substances; the exterior, called *cortex;* the interior, *medulla.*[d]

"Each abounds in blood-vessels; but the cortical portion has likewise very minute colourless tubes which "are the origins of the uriniferous ducts[e]; the medullary part contains these ducts. The blood-vessels are distributed in rather a reticulated manner among the tubes, with which they have no communication of canal. Small round hollow bodies are also seen, containing blood, and connected with the blood-vessels, but with them only.[f]

"These tubes arise, in the manner formerly described" in regard to the bile ducts, from minute blind extremities, not dilated, but nearly of the same diameter as the rest of the canal, and "formed in the cortical part; of which they constitute the greatest portion." They preserve an angular course in the cortica part; but in the medullary, where they are called the Bellinian tubes, they run straight. The cortical part "principally consists of them; and, after they have coalesced into fewer trunks, their mouths perforate, in the form of so many cones,



a, cortical part.
b, medullary.
c, papillæ.
d, infundibula.
e, pelvis.
f, ureter.

[c] "Eustachius, *tabulæ,* i.—v., which belong to his classical work *De renibus* published with this great man's other *Opusc. anatom.* Venet. 1564. 4to. Also tab. xii."

[d] "C. W. Eysenhardt, *De structura renum Observationes Microscopicæ.* Berol. 1818. 4to."

[e] "These appear to have imposed upon Ferrein as a new description of vessels which he called neuro-lymphatics, or white tubes, and of which he imagined the whole parenchyma of the viscera to be composed. He affirmed that they were of such tenuity, that their length in each kidney of an adult man was equal to 1000 orgyiæ (60,000 feet) or five leagues."

[f] Mueller, *De glandularum secernentium, &c.* p. 102.

like a sieve, the *papillæ* of the pelvis of the organ [g]," or, more properly, the rounded ends of these cones project as so many papillæ.

" These papillæ usually correspond in number with the lobes which form the kidneys, and they convey the urine, secreted in the colourless vessels of the cortex and " " the Bellinian tubes of the medulla, into the *infundibula*," or little membranous canals which at one end surround the duct or papilla, and at the other " unite into a common *pelvis*.

" The pelvis is continued into the *ureters*, which are membranous canals, very sensible, lined with mucus, extremely dilatable, generally of unequal size in the human subject in different parts [h], and inserted into the posterior and inferior surface of the bladder in such a way, that they do not immediately perforate its substance, but pass a short distance between the muscular and cellular coats, which at that part are rather thicker than elsewhere, and finally open into its cavity by an oblique mouth. This peculiarity of structure prevents the urine from regurgitating into the ureters from the bladder."

As the ureters have a tendency to lose this obliquity of insertion in proportion as the bladder is depleted, two long bands of muscular fibres run from the back of the prostate gland to the orifices of the ureters, and not only assist in emptying the bladder, but, at the same time, pull down the orifices of the ureters, and thus tend to preserve the obliquity.[i] When the bladder is distended, and the urine flows with difficulty into it, the fluid accumulates in the ureters, and, as the obliquity greatly lessens as soon as the bladder is emptied, the urine then flows freely into it, and persons, after making a large quantity of urine, thus very soon make another quantity.

" The urinary *bladder* [k]," oviform in the adult, but " varying in shape according to age and sex, is generally capable, in the adult, of containing two pints of urine. Its fundus, which in the fœtus terminates in the urachus, is covered posteriorly by the peritonæum. The other coats correspond with those of the stomach.

" The *muscular* consists of interrupted bands of fleshy fibres,

[g] " Eustachius, tab. xi. fig. 10."

[h] " See Nuck, *Adenographia*, fig. 32. 34, 35. Leop. M. Ant. Caldani, *Saggi dell' Accad. di Padova*, t. ii. p. 2."

[i] Sir C. Bell, *Med. Chir. Trans.* vol. iii.

[k] " Duverney, *Œuvres anatomiques*, vol. ii. tab. i.—iv."

variously decussated, and surrounding the bladder.[l] These are called the detrusor urinæ: the fibres which imperfectly surround the neck, and are inconstant in origin and figure, have received the appellation of sphincter.

" The *cellular* chiefly imparts tone to this membranous viscus.

" The *interior*, abounding in cribriform follicles [m], is lined with mucus, principally about the cervix.

" The urine conveyed to the bladder gradually becomes unpleasant by its quantity, and urges us to discharge it. For this purpose the *urethra* is given, which " is a canal beginning at the lowest part of the bladder, much longer in the male than the female, and attached to the arch of the pubes by muscular fibres that are described by Mr. Wilson under the name of compressor urethræ and conceived to act as the sphincter of the bladder, " varies with the sex, and will be farther considered in our account of the sexual functions.

" The bladder is evacuated from the constriction of the sphincter being overcome both by the action of the detrusor and by the pressure of the abdomen." The assistance of the abdominal muscles, however, is not absolutely requisite, however greatly it may contribute; because, if we keep them motionless, and direct our attention to the bladder, when it contains urine, a sensation is immediately felt at its neck; and if we still fix our attention, we can will the passage of the urine through it, probably by willing a relaxation of the muscular fibres of the part, as much as by willing a contraction of the detrusores fibres, — the diaphragm and abdominal muscles being still preserved motionless. " The last drops of urine remaining in the bulb of the" male " urethra are sent forth by the ejaculatores seminis.

" The nature of the *urine* varies infinitely [n] from age, season of the year, and especially from the length of the period since food or drink was last taken, and also from the quality of the

[l] " Santorini's posthumous tables, xv."

[m] " Flor. Caldani, *Opus. anat.* Patav. 1803. 4to. p. 4."

[n] " See Hallé, *Mém. de la Soc. de Médecine*, vol. iii. p. 469. sq."

[o] " The specific quality of some ingesta manifest themselves in the urine so suddenly, even while blood drawn from a vein discovers no sign of their presence, that philologists have thought there must be some secret ways leading directly from the alimentary canal to the kidneys, besides the common channels. An examination of them will be found in Aug. H. L. Westrumb's Commentary (honoured with the royal prize) *de phenomenis, quæ ad vias sic dictas lotii clandestinas demonstrandas referuntur.* Gotting. 1819. 4to., and P. G. C. E. Bark-

ingesta[o], &c. The urine of a healthy adult, recently made after a tranquil repose, is generally a" clear " watery fluid of a nidorous smell" while warm, " and of a lemon " or amber " colour," saline, bitter, and disagreeable to the taste, " and contains a variety of matters[p] held by a large quantity of water in solution, and differing" in their absolute quantity in different persons, and in the same person at different times.

The more aqueous fluid is taken, and the less the skin and lungs secrete, as in cold weather, the larger the amount of water in the urine, which is then paler, more copious, and lighter. The opposite circumstances, as well as exercise or feverishness, render it high coloured, scanty, and heavy. Its usual specific gravity is from 1015 to 1025. Much of the matters dissolved subside in the form of a pale brown or reddish sediment after it has stood, if the individual is feverish or dyspeptic, and the temperature to which it is exposed is low; and they dissolve again if it is warmed. The quantity made daily by adults in health, though much influenced by the quantity of liquids drunk, is, perhaps, on the average, about three pints in the twenty-four hours. After standing some time, the urine, which, when first made in health, is acid, becomes alkaline, emits a strong ammoniacal smell, and is covered with a white mucous pellicle, in which, as well as on the sides of the vessel, crystalline phosphate of magnesia and ammonia is seen: yellow cubic crystals of chloride of ammonia are then deposited, next yellow octohedrons of chloride of ammonia, and lastly microcosmic salt or the fusible salt of the urine,—phosphate of magnesia and ammonia. The fluid in the mean time becomes a brown and fœtid syrup.

The following is Berzelius's analysis of urine, in 1809[q]:—

Water - - - -	933·00
Uric acid - - - -	1·00

hausen's Dissertation (which gained the second prize) *de viis clandestinis urinæ*. Berol. 1820. 8vo."

Sir Everard Home observed, in his experiments on the spleen, that colouring matters began to manifest themselves in the urine about seventeen minutes after they were swallowed, became gradually more evident, then gradually disappeared, and after some hours, when the mass had unquestionably passed into the intestines, again tinged it as strongly as ever.

[p] See Fr. Stromeyer, *Theoret. chimie*, t. ii. p. 609.

[q] *Med. Chir. Trans.* vol. iii.

Urea - - - -	30·10
Sulphate of potass - - -	3·71
Sulphate of soda - - -	3·16
Phosphate of soda - - -	2·94
Chloride of sodium - - -	4·45
Phosphate of ammonia - - -	1·65
Chloride of ammonia - - -	1·50
Free lactic acid - - - Lactate of ammonia - - - Animal (extractive) matter soluble in (anhydrous) alcohol, and usually accompanying the lactates - - - Animal matter insoluble in alcohol - Urea, not separable from the preceding -	17·14
Earthy phosphates with a trace of fluate of lime	1·00
Mucus of the bladder - -	0·34
Silex - - - - -	0·03
	1000·00

In the urine of young children and herbivorous animals benzoic acid is found, united with animal matter, and perhaps thus exists as a peculiar acid, for which Berzelius proposes the name of uro-benzoic acid.[r]

According to some, urine, like the blood, affords carbonic acid gas under the receiver of an air-pump[s], and more after a meal[t]; but others regard its presence as accidental, from not having been able to find it.[u]

Uric acid is in the form of soft white scales, without taste or smell, requiring a thousand times its weight of cold water for its solution, and nearly as much of boiling water. According to Dr. Prout it consists of

Nitrogen - - -	31·125
Carbon - - -	39·875
Hydrogen - - -	2·225
Oxygen - - -	26·775

The urine contains much more uric acid in solution than an equal quantity of boiling water would dissolve. Hence Dr. Prout con-

[r] *Traité de Chimie*, t. vii. p. 363. 1833.
[s] Vogel, *Annales de Chimie*, t. xciii.
[t] Mr. Brande, *Phil. Trans.* 1810.
[u] Berzelius, l. c. and Whoeler.

ceives that it is in the state of urate of ammonia, which is decomposed by the other acids when it cools: while others fancy that the solution in the urine of substances so little soluble is a fact analogous to that of iodine being so much more soluble in water charged with chloride of sodium or ammonia.

Urea is in the form of slender four-sided prisms, colourless, inodorous, and deliquescent, and affords a cool taste like nitre: it reacts as neither an acid nor an alkali.

It is a common mistake, even at present, to ascribe the colour and smell of urine to it. Whoeler has shown that urea is a cyanite of ammonia. Dr. Prout has established that it consists of

Hydrogen - -	·266
Carbon - - -	·799
Nitrogen - - -	1·866
Oxygen - - -	1·066
	4·000[x]

The large proportion of nitrogen in urea leads to the conclusion that the kidneys are the great outlet for azote, as the lungs and liver are for carbon.

In disease, the specific gravity may exceed 1050, and the quantity has been greater than thirty pounds a day. Dr. Peter Frank had a patient who made forty pounds every twenty-four hours, and occasionally fifty-two pounds[a]; and he knew it exceed the weight of the body in a few days. On the other hand, no urine has sometimes been secreted for twenty-two weeks.[y] Dr. Richardson mentions a lad of seventeen who had never made any, and yet felt no inconvenience.[z] In disease, and even during such little derangements as are scarcely considered disease, the urine deposits sediments, lateritious and pink; and Dr. Prout has shown that they consist chiefly of the urate of ammonia, and states that they are formed from the albuminous portions of the chyle. The red colour he has shown to depend upon the presence of the purpurate of ammonia, — a substance formed from the uric acid, and which, like the other purpurates, colours the urates pink. When the usual yellow colouring matter is present, this, with the pink,

[x] *Med. Chir. Trans.* vol. viii. p. 535.

[y] Haller, *Biblioth. Medic.* vol. ii. p. 200.

[z] *Phil. Trans.* 1713. He had a constant diarrhœa.

[a] *De curandis hominum morbis*, lib. v. p. 44.

causes the sediment to be red — of various hues, according to the proportions; and, when the colouring matter is absent, as in hectic, the sediment is pink.[b]

Various odorous and coloured principles pass off with the urine; as turpentine, balsams, asparagus, on the one hand, and red fruits, cactus opuntia, rhubarb, indigo, &c. on the other. Mercury, iron, and prussiate of potass will enter into it; as well as tartaric, oxalic, gallic, succinic, benzoic, malic, and citric acids, or at least these will render it acid. Alkaline borates, carbonates, silicates, chlorates, and nitrates, also pass off by the kidney. But the neutral salts of potass and soda with vegetable acids are decomposed; the alkali only, in the state of carbonate, being found in the urine. Mineral acids, alcohol, camphor, empyreumatic animal oil, musk, cochineal, turnsol, le vert de vessie, and orcanette, with the oxides of iron, and preparations of lead and bismuth, when taken, are not found in it.[c]

The urine may be deranged as remarkably as the sweat. For it is sometimes blue, from containing indigo not taken into the system, as I have seen through the kindness of Dr. Prout, and from other substances; and blueness of it appears to be produced sometimes by Prussian blue swallowed. Sometimes it is black, perhaps from containing a peculiar acid, called melanic, without any danger to the health. Dr. Prout has shown me two specimens of this, in which the sediment was perfectly black; and it may contain not only the albumen and red particles of the blood, but absolutely sugar, and occasionally new substances found nowhere else.

The urine of birds is generally discharged with the fæces, becomes solid by exposure to the air, and contains a large quantity of biurate of ammonia. Urea exists in the urine of carnivorous birds, not in that of the herbivorous. Dr. Wollaston found the uric acid to be only $\frac{1}{200}$ in a goose feeding on nothing but grass; and in birds taking nothing but animal food, to constitute nearly the whole mass. That of serpents is discharged only once in some weeks, is of a caseous consistence, and likewise becomes perfectly solid afterwards. It is almost entirely uric acid, and superurates of potass, soda, and ammonia.[d] The urine of the turtle

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[b] Gultstonian Lectures delivered before the College of Physicians. *London Med. Gazette*, 1833.

[c] Berzelius, l. c.

[d] Dr. Prout, *Thomson's Annals of Philosophy.* Dr. Davy, *Phil. Trans.* 1818.

and tortoise is also destitute of urea, but does not contain urate of ammonia so pure. That of the frog and toad contains urea, chloride of sodium, and a little phosphate of lime.[e] The urine of fish, as well as of birds and reptiles, and the kidneys of mollusca, contain uric acid.[f] In oviparous animals the urine is formed from venous blood, the kidneys having a double venous circulation, exactly as is the case with the human liver.[g]

The urine of carnivorous mammalia contains uric acid and urea; while that of herbivorous brutes contains uro-benzoates and urea, but no uric acid, and is generally deficient in phosphates, which are replaced by carbonates.

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[e] Consult Berzelius, l. c. [f] Ibid.

[g] Dr. Jacobson, *De system. venos. peculiari in permultis animalibus observato.* Hafniæ, 1821; and *Edinb. Med. and Surg. Journ.* vol. xix. p. 78.

CHAP. XVIII.

THE FAT.

In many parts of the body a fluid exists, which must be considered before we close our account of the production, application, and purification of the blood — or, in other words, of the natural functions. The *fat*, in truth, nourishes the body, when food cannot be procured or cannot be assimilated.

" The *fat*[a] is" a yellow " oily fluid, very similar in its general character to vegetable oils[b], bland, inodorous, lighter than water; containing" oleine, stearine, glycerine, and margaric and oleic acids — substances, together with some others, found in the fatty secretions of different animals. Stearine is the solid principle, and oleine the fluid principle, of oils. It consists ultimately of carbon, oxygen, and hydrogen.

Carbon - -	79·000
Oxygen - -	9·584
Hydrogen - -	11·416

" When secreted from the blood and deposited in the mucous tela, it exists in the form of drops, divided by the laminæ of the tela, in a manner not unlike that in which the vitreous humour of the eye is contained in very similar cells.

" The relation of fat to different parts is various.

" In the first place, some parts, even those whose mucous tela is extremely soft and delicate, never contain fat. Such are the palpebræ and penis.

" In very many parts, it is diffused indefinitely, especially in the *panniculus adiposus*, the interstices of the muscles, &c.

" In some few, it is always found, and appears to be contained in certain definite spaces, and destined for particular purposes. Such we consider the fat around the basis of the heart[c]: and in

[a] " W. Xav. Jansen, *Pinguedinis Animalis Consideratio Physiologica et Pathologica.* Lugd. Bat. 1784. 8vo."

[b] " J. D. Brandis, *Comm.* (rewarded with the royal prize) *de oleor. unguinosor. natura.* Gotting. 1785. 4to. p. 13."

[c] " Hence it is clear how many exceptions must be made to the assertion of

the mons veneris, where it forms a peculiar and circumscribed lump.[d]

" Its consistence varies in different parts. More fluid in the orbit, it is harder and more like suet around the kidneys.

" It is of late formation in the fœtus; scarcely any trace of its existence is discoverable before the fifth month after conception."

It is accumulated under the skin chiefly in the first years of childhood, and again between the fortieth year and old age. Women grow fat earlier, and especially if married. In old people it gradually lessens, like all solids and fluids, till they are wrinkled, shrivelled, and very light.

" There have been controversies respecting the mode of its secretion: some, as W. Hunter, contending that it is formed by peculiar glands; others, that it merely transudes from the arteries. Besides other arguments in favour of the latter opinion, we may urge the morbid existence of fat in parts naturally destitute of it; — a fact more explicable on the supposition of diseased action of vessels, than of the preternatural formation of glands. Thus, it is occasionally formed in the globe of the eye; a lump of hard fat generally fills up the place of an extirpated testicle; and steatoms have been found in almost every cavity of the body."

Dr. William Hunter contended that the fat is not contained in the same cells of the cellular membrane as the fluid of anasarca, but in distinct vesicles: because, — 1. The marrow, which strongly resembles fat, is contained in vesicles or bags; 2. Parts which are not loaded with anasarca, as the eyelids, never contain fat; 3. In dropsical subjects, exhausted of the fat, the membrane which contained fat appears still very different from the other, — that immediately under the skin, for example, being thin and collapsed, while that opposite the tendon of the latissimus dorsi is thick and gelatinous; 4. Parts which become filled with fluid from gravitation in dropsy, as the penis and scrotum, never contain a drop of oil in the fattest persons; 5. Dropsical parts pit on pressure; the fluid disperses, and returns when the pressure

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the celebrated Fourcroy, — that fat is an oily matter, formed at the extremities of arteries, and at the greatest distance from the centre of motion and animal heat. See his *Philosophie Chimique*, p. 112."

[d] " I found this still more distinct in the body of a female of the species *simia cynomolgus*, from which, by means of cold, I was able to remove it with its symmetrical form entire."

is resumed. This is not the case with parts distended by fat, although it is when oil is poured into the common cellular membrane after death.[e]

The intestines occasionally discharge fat; sometimes solid, sometimes fluid, but concreting quickly on cooling. I have seen such cases, and published a full history of the subject two years ago.[f]

" The glands which some celebrated characters have contended secrete the fat, are only imaginary.[g]

" Whatever may be the truth of this matter, the deposition and absorption of the fat take place with great rapidity.

" The use of the fat is multifarious.

" It lubricates the solids and facilitates their movements; prevents excessive sensibility; and, by equally distending the skin, contributes to beauty." It probably supports mechanically, and lessens shocks; and preserves the temperature of the body, like an inner garment.

" We pass over the particular uses of fat in certain parts, *v. c.* of the marrow of the bones.

" During health, it contributes little or nothing to nourishment."[h] But as soon as food or chyle is deficient, or great evacuations occur, it is absorbed, in order to afford as much nourishment as possible.

Fourcroy fancied " that it affords a receptacle for the super-

Medical Observations and Inquiries, vol. ii. p. 33. sqq.

Med. Chir. Trans. vol. xviii. I give cases of its discharge from both bowels and urinary bladder: and one of its discharge from the intestines, while the kidneys were discharging sugar and the lungs pus. Ambergris is a fatty matter found in the intestines of the spermaceti whale, but never higher than six or seven feet from the anus. Its quantity has exceeded a hundred pounds, and, though so frequently discharged as to be found on the shore and floating on the waves, accumulation, or the state which occasions it, sometimes appears to destroy life. It is more abundant in proportion as the animal is costive and sickly. l. c.

Some birds nourish their young with an oily substance, secreted in their own stomachs. This is so copious in the petrel, that, in the Faro Isles, people use petrels for candles, merely passing a wick through the body from the mouth to the rump. *Pennant, Brit. Zool.* vol. ii. p. 434.

[g] " The singular opinion of the distinguished Home, respecting the origin and use of the fat, *viz.* that it is formed in the large intestines, chiefly by the instrumentality of the bile, and that it supplies a kind of secondary nourishment to the body, will be found fully described in the *Phil. Trans.* 1813. p. 146."

[h] " P. Lyonet conjectures, with probability, that insects destitute of blood derive their chief nourishment from the fat in which they abound. *Tr. anat. de la Chenille qui ronge le bois de Saule*, pp. 428. 483. sq. and the Preface, p. xiii."

fluous hydrogen, which could not otherwise be easily evacuated."[i]

The fattest person on record is, I believe, Lambert of Leicester. He weighed seven hundred and thirty-nine pounds[k], and died at the age of forty years. In him rats and mice might certainly have nested, if it is true that a bishop of Mentz, or

> " A Saxon Duke, did grow so fat
> That mice (as histories relate)
> Ate grots and labyrinths to dwell in
> His postique parts without his feeling."[l]

Excessive formation of fat may be strongly opposed by regularly taking great exercise, little sleep, and little, but dry, food.[m] Fretfulness of temper, or real anxiety of mind, will prevent any one from getting fat, and make any fat man thin. A passage that occurs in the most magnificent of Shakspeare's Roman plays, and is founded on some information of Plutarch's, will instantly be remembered.

> *Cæsar.* Let me have men about me that are fat;
> Sleek-headed men, and such as sleep o' nights;
> Yond' Cassius has a lean and hungry look;
> He thinks too much: such men are dangerous.
> *Antony.* Fear him not, Cæsar, he 's not dangerous;
> He is a noble Roman, and well given.
> *Cæsar.* 'Would he were fatter:— But I fear him not:
> Yet if my name were liable to fear,
> I do not know the man I should avoid
> So soon as that spare Cassius.[n]

Great obesity occurs sometimes in infants. I saw a prodigiously fat female, but a year old, who weighed sixty pounds, and

[i] " See Fourcroy, l. c.

[k] Dr. Good says that some German Journals mention cases of eight hundred pounds weight, but he gives no references.

[l] *Hudibras*, P. ii. Canto i.

[m] Semper vero et certissime debellanda (obesitas), si modo bona voluntas et vis animi fuerit, valida corporis exercitatione, brevi somno, parca et sicca diæta. Nec facile miles gregarius repertus fuerit, qui tali morbo laborat. Dr. Gregory, *Conspectus Med. Theor.* lxxxix. Iodine is the best *medicine* against it.

See the intructive case of the Miller of Billericay, in the *Transactions of the Royal College of Physicians, London*, vol. ii.

A large collection of cases of obesity will be found in Mr. Wadd's *Cursory Remarks on Corpulence*.

[n] *Julius Cæsar*, act i. scene 2.

had begun to grow fat at the end of the third month. She was also of Herculean general development, and, like many dwarfs, had a flat nose. At an early age I believe females are more commonly the subjects of the affection than males.

A Frenchman named Seurat, who was shown in London a few years ago, with the soubriquet of the "Living Skeleton," was probably as extreme an instance of emaciation as can be imagined. An American, named Calvin Edson, shown more lately, was also extraordinarily emaciated, and weighed but 58 lbs. They had no other apparent disease. The Frenchman was about 30 years old, and had wasted from infancy: the American about 40, and had wasted for sixteen years. A French penny roll and a little *vin du pays* was the Frenchman's daily food in France; and in England a little meat, amounting, with a reduced portion of bread, to three ounces per diem.

The fatty substance of various animals has various properties, and affords various principles. Vegetables contain fatty substances volatile as well as fixed.

Starch is hoarded in plants in small cells, into which the sap penetrates and then dissolves it, so that it becomes nourishment to the plant, under particular circumstances, just as fat does to animals. This is the purpose of the stock of fecula in tuberose roots.

CHAP. XIX.

THE NERVOUS SYSTEM.

We now arrive at the animal functions — those which consist of feeling and the exertion of a will, — those, therefore, which, in their nature, must be peculiar to animals.

The organs of these functions are, the *encephalon*, *spinal chord*, and *nerves*. These, together with bodies called *ganglions*, constitute the nervous system.

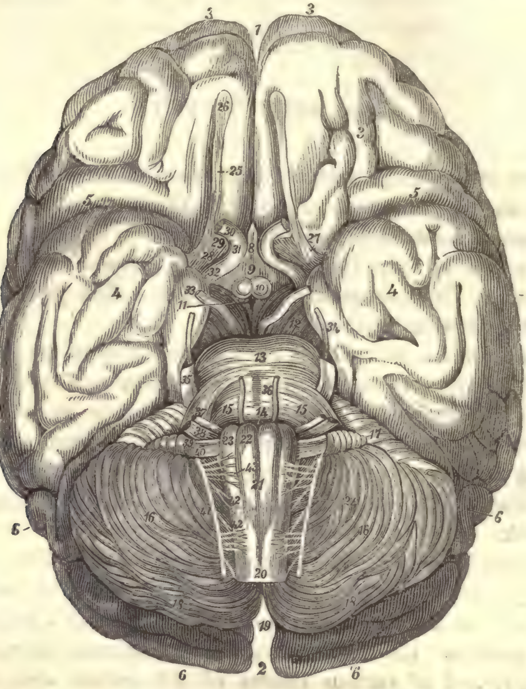
The *encephalon*, or brain, is encased in the cranium; the *spinal chord*, or improperly, spinal marrow, or spinal prolongation of the brain, in all the vertebræ, down to the first or second lumbar; the *nerves* pass through openings in the skull, between the vertebræ, and in the sacrum, and run in all directions through the system; while the *ganglions* are disseminated in the head, neck, and trunk.

The *encephalon* is the largest solid organ found in the cavities of the body, except the liver. Its substance is not firm, and on exposure to the air grows very soft. It consists of a pulpy and a fibrous portion. Its more external part, and some internal parts, are pulpy, and of various shades of ash colour and yellowish brown. The chief portion is fibrous and white. It is, therefore, said by some to consist of a cortical or cineritious, and of a medullary or white, portion: but what is not white is not always cortical, neither is its hue always cineritious; and the white fibrous portion is totally different from what is properly called marrow. Gall, therefore, more properly, says it consists of a pulpy and a fibrous portion.[a]

[a] "We could wish that the term *medulla* were banished from the nervous system. The functions of nerves are totally different from those of marrow, and infinitely more noble. Besides, the idea of marrow always excludes fibrous structure." (*Anatomie et Physiologie du Système Nerveux, et du Cerveau en particulier*, 4 vols. 4to. Paris, 1810—19, with an atlas of 100 plates Vol. i. p. 49.)

While some had said that the white part was all blood-vessels, others that it contained none, some that it, as well as the cineritious part, was all globules, some that it was solid, others tubular, Leuwenhoeck, Vieussens, and Stenon,

It consists of four masses: one many times larger in the adult than the second, and called *cerebrum;* a second, called *cerebellum,*



pronounced it fibrous; and Bonnet, Herder, and many others, conceived a fibrous structure so fit for the operations of the mind that they adopted this opinion. But Soemmering and Cuvier did not venture to consider it fibrous throughout; and many moderns, — the brothers Wenzel, for instance, — declared that, after repeated experiments and most careful observation, the brain was not at all fibreus, but equally pulpy throughout. Walter, Ackerman, and Bichat equally deny the fibrous structure of the brain, and speak of the white part as only medullary. (Gall, l. c. vol. i. p. 235.)

Professor Ehrenberg has lately found the proper substance of the brain and nerves to be fibrous, under a microscope with a power of magnifying to 300 or even to 800 diameters. In the white part of the the brain, he says, the fibres are straight and cylindrical, with others like strings of pearls: in the medullary, these knotted fibres only exist, contained in a dense network of blood-vessels, and interspersed with plates and granules. He declares the large cylindrical fibres to be tubular, and believes that the knotted are tubular also. All microscopical observations require careful repetition by many individuals. (Poggendorf's *Annalen der Physik und Chimie,* No. 7. 1833.)

1. Anterior extremity.
2. Posterior extremity, of the great central fissure of the cerebrum.
3, 3, 3. Its anterior lobes.
4, 4. Its middle lobes.
5, 5. Fissure of Silvius, separating the anterior from the middle.
6, 6. Posterior lobes.
7, 7. Convolutions of the external surface of the hemispheres.
8. Infundibulum.
9. Tuber cinereum.
10. Corpora pisiformia.
11. Grey substance between them; and,
12. The anterior prolongations of the mesocephalon, or crura cerebri.
13. Inferior surface of the mesocephalon, and the groove which lodges the basilar artery.
14. Groove separating the mesocephalon and the superior extremity of the chorda oblongata.
15, 15. Posterior prolongations of the mesocephalon, or crura cerebelli.
16, 16. Inferior surface of the lobes of the cerebellum.
17. Anterior, and
18, 18. Posterior, parts of the circumference of the cerebellum.
19. Fissure separating the lobes of the cerebellum behind.
20. Superior extremity of the spinal chord.
21. Central groove, which divides
22. The corpora pyramidalia.
23. Corpora olivaria.
24. Corpora restiformia.
25. Olfactory nerve,
26. Its bulb,
27. Extent,
28. Its middle, and
29. Internal, root.
30. Optic nerves after their decussation.
31. Their decussation.
32. Optic nerves before their decussation.
33. Common motor nerve of the eye.
34. Internal motor, or pathetic, nerve.
35. Trigeminus or trifacial.
36. External motor nerve of the eye.
37. Facial nerve.
38. Acoustic nerve.
39. Glosso-pharyngeal or gustatory.
40. Pneumono-gastric or vagus.
41. Accessory.
42, 42. Fibres of reinforcement of the accessory.
43. Roots of the hypoglossal, plunged in the groove between the paramidal and olivary bodies. (Gall.)

and placed below the posterior part of the cerebrum; a third, which unites these, is much smaller than the second, and called *mesocephalon* or tuber annulare or pons Varolii; and an apparent prolongation of this, still smaller, and termed *chorda oblongata* or medulla oblongata; an apparent prolongation of which, again, is the chorda, or medulla, spinalis.

The *cerebrum* is divided down to its middle into two equal portions, termed *hemispheres.* Each of these, again, consists of three portions or *lobes;* an anterior, a middle, and a posterior. The outermost part of the cerebrum is rendered far more extensive than the dimensions of the organ, by these divisions; and still more by being furrowed to about an inch in depth, the two sides of each furrow being in contact, so that what are termed *convolutions* exist. The inner surface of the small intestines is greatly increased by projections of the mucous membrane; the inner surface of the lungs, and of glands, by being divided into innumerable tubes and cells: whence there is far more absorption of chyle, far more changes of the blood and air, and far

Superior surface of the cerebrum, narrower at the front than at the back; divided into two hemispheres, and consisting of convolutions. — In the cut at p. 304. the lobes are seen.

more secretion, in these respective parts, than there otherwise could be. As an equally beautiful contrivance augments the surface of the cerebrum, and of the portion immediately subjacent, we may be certain that the more external parts — those portions which are thus rendered more extensive (for the mass is rather diminished by the contrivance) are of the highest importance; and, as the inner surfaces, thus augmented, are all the seat of the functions of the respective organs, we may, perhaps, presume that, in the case of the cerebrum, the seat of chief function is the more superficial portions. Even a little more increase is effected by the summit of many convolutions being depressed. In the same way, the cerebellum is divided into two lobes, and these into sixteen lobules; the surface of each lobe consists of about sixty plates, standing side by side; and even in the sides of these are others, secondary, seen only on separating the primary, and amounting, perhaps, to 600 or 700. The purpose must be the same. We

shall find the surface farther augmented by cavities, and the surface of these cavities also increased by irregularities.[b]

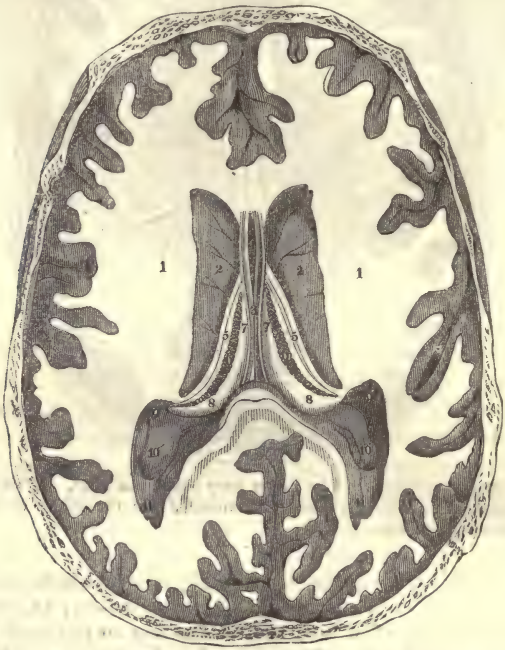
On cutting the hemispheres of the cerebrum away by successive horizontal slices, we find the mass white and the outermost portions grey. When the hemispheres are entirely removed, a continuous surface remains, called *centrum ovale;* the two halves

The cranium is external. The pulpy grey substance next. Then the fibrous white substance or centrum ovale. The mesolobe in the midst of it; and the raphè in the centre of this.

[b] M. Desmoulins contends, 1st, that integrity of surface is the only condition constantly necessary for the production of nervous actions; 2d, that these are proportionate to extent of surface; and, 3d, that they are performed by the surface, and transmitted from it. The energy of an electric apparatus depends very much upon surface. Dr. Spurzheim asks whether it is not on this account that the encephalic masses are hollow or convoluted; and remarks that the nervous masses of the lower animals are very commonly hollow. *The Anatomy of the Brain,* by G. Spurzheim, M.D., p. 206. London, 1826.

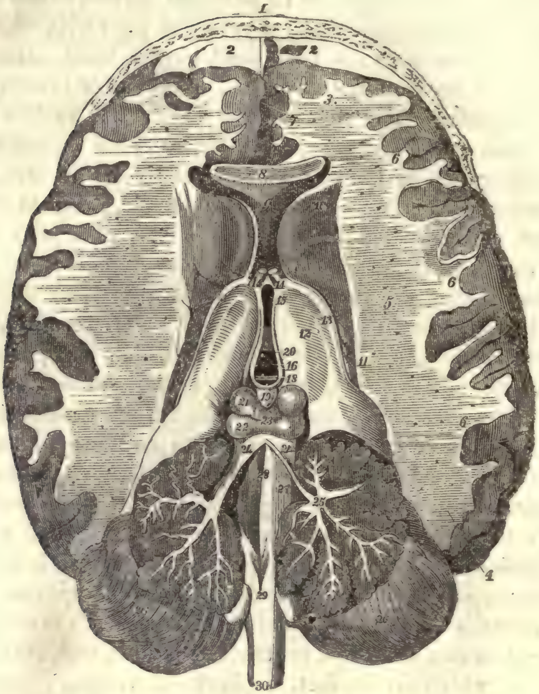
Dr. Macartney has lately declared that the surface of the human brain is thus proportionately more extensive than that of any other animal. *Second Report of the British Scient. Assoc.,* p. 454.

being united in the centre, and their commissure being termed *mesolobe* or corpus callosum. It has a longitudinal depression, called *raphè* or suture. When still more is removed horizontally, a large cavity appears immediately on each side of the centre, called the *lateral ventricle:* which runs forwards into the anterior lobe, making an *anterior cornu;* backwards into the posterior lobe, making a *posterior cornu,* ending like a finger, and thus forming what is called a *digital cavity;* and downwards into the middle lobe, making an *inferior cornu.* A septum exists between the two lateral ventricles, called *septum lucidum,* with a little space called the *fifth ventricle* between the two layers of which it consists. In each lateral ventricle is a white mass, called *thalamus*



Horizontal view of the cerebrum, sufficient being cut away to exhibit, 1, 1, the great mass of white fibrous substance, surrounded on the surface by the grey pulp. 2, 2. Corpora striata, and lateral ventricles. 3. Septum lucidum. 4. Fifth ventricle. 5, 5. Semicircular band separating the corpora striata from the thalami optici, upon which lie, 6, 6, the plexus choroides. 7, 7. Fornix. 8, 8. Its posterior pillars, turning round to face the fimbriated bodies. 9, 9. Part where the superior part of the lateral ventricles communicates with the inferior, which is not seen. 10, 10. Ergot. 11, 11. The posterior part or digital extremity of the lateral ventricles.

opticus, with two tubercles on its posterior border, called external and internal *corpora geniculata ;* a yellowish mass with white striæ, called *corpus striatum ;* a pale semicircular band, called *tænia semicircularis*, between the two ; and a plexus of vessels, called *plexus choroides*. The floor of the cavity has various prominences : one called *hippocampus major*, or *cornu ammonis*, which is a prolongation of the posterior extremity of the mesolobe in the inferior cornu ; and a small one of the same kind in the posterior cornu, called *hippocampus minor*, or *ergot ;* another called *corpus fimbriatum*. Under the septum is another long white body called the *fornix*, with a few transverse lines called *lyra* at its lower surface, extended over a *third ventricle*, which is placed exactly in the centre, and to which an opening leads at each side of the fornix from the corresponding lateral ventricle. The anterior extremity of the fornix divides into two pillars, which diverge and run down to two projections at the base of the brain, called *corpora mammillaria*, *pisiformia*, or *albicantia*, between which is a grey triangular plate, called *pons Tarini :* its posterior extremity does the same, and each posterior division itself divides into two, one of which is the corpus fimbriatum ; and between this and the thalamus opticus exists a chink through which the pia mater, or innermost covering of the brain, enters into the third ventricle and unites with the plexus choroides, which is, in fact, a plexus of vessels, connected by cellular membrane, called, in this part of the body, pia mater. At the posterior extremity of the fornix are seen four eminences, called *corpora quadrigemina ;* the two higher and larger called *nates*, or *c. q. anteriora ;* the two smaller and lower called *testes*, or *c. q. posteriora ;* and, before them all, is a grey body, called *pineal gland*, generally containing grit, and attached to the brain by two medullary prolongations only, which run to the thalami optici. Behind and below the corpora quadrigemina, is a fine layer of transverse greyish fibres, called *valve of Vieussens*, which is formed by three converging bands, named *processus a cerebello ad testes*. Three bands of white matter, called *commissures*, run transversely over the *third ventricle*, establishing more communication between the two halves of the cerebrum. The anterior part of the floor of the third ventricle is formed by the upper surface of a small grey body, called *tuber cinereum*, which runs downwards in a conical form under the name of *infundibulum*, and ends in a little mass called *pituitary gland*, and lodged in the fossa

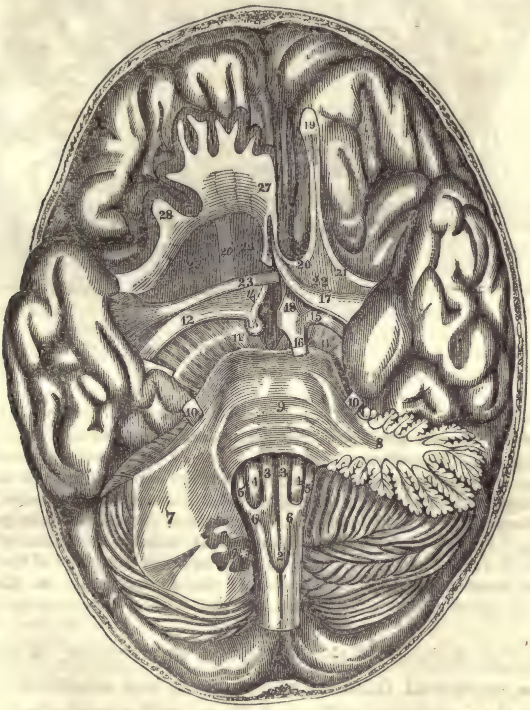


A transverse section of the brain, on a level with the lateral ventricles. The upper part of the corpus callosum, together with the fornix, removed, so as to expose the upper part of the lateral ventricles, the middle ventricle, the corpora striata, the optic thalami, tubercula quadrigemina, and the pineal gland with its prolongations. The valve of Vieussens and the cerebellum are divided in the middle line, and separated to expose the fourth ventricle and the calamus scriptorius. 1. Transverse section of the frontal bone. 2, 2. Cranial surface of its orbitar plate. 3. Anterior extremity of the cerebral hemispheres. 4. Posterior extremity of the same hemispheres. 5. White substance of the hemispheres. 6, 6, 6. Thin grey substance. 7. Anterior part of the interlobular fissure. 8. Cut in the anterior extremity of the corpus callosum. 9. Bent-back portion of the anterior extremity of the corpus callosum, placed between the corpora striata. 10. Anterior extremity of the corpus striatum. 11. Posterior extremity of the corpus striatum, and upper part of the lateral ventricle. 12. Thalamus opticus. 13. Semicircular band between the thalamus and corpus striatum. 14, 14. Anterior pillars of the fornix, divided near their origin. 15. Anterior, and, 16. Posterior, extremity of the middle ventricle. 17. Nervous band or middle commissure, uniting the thalami in the interior of the middle ventricle. 18. Posterior commissure. 19. Pineal gland. 20. Medullary prolongations of the pineal gland in the internal part of the optic thalami. 21. Tubercula quadrigemina superiora. 22. Tub. quad. inferiora. 23. Crucial furrow between them all. 24, 24. Valve of Vieussens divided, and each half turned back. 25. Vertical section of the cerebellum and arbor vitæ. 26, 26. Superior surface of the cerebellum. 27. Fourth ventricle. 28. Central groove

running from the aqueduct of Sylvius and the upper surface of the cerebral protuberance to the upper surface of the spinal chord, and united to, 29. the cavity commonly called calamus scriptorius. 30. Upper extremity of the spinal marrow.

seen on the upper part of the ethmoid bone, before the corpora albicantia. (Cut, p. 304.) From the posterior part of the third ventricle a canal, called *aquæductus Sylvii*, or *iter a tertio ad quartum ventriculum*, runs back, under the base of the corpora quadrigemina, into a cavity in the cerebellum called the *fourth ventricle.*

On cutting the *Cerebellum*, which has two lobes united by a projecting portion called *vermiform process* at the superior-anterior and superior-middle part, we find it less consistent than the other parts of the encephalon. Its fibrous substance within is collected into three masses; two lateral, and sending off prolong-



1. Continuation of the central fissure of the spinal chord. 2. Beginning of the anterior pyramids. 3, 3. Anterior pyramids. 4, 4. Corpora olivaria. 5, 5. Corpora restiformia. 6, 6. Cross band uniting the corpora olivaria. 7. Horizontal

section of the cerebellum· 7*. Ganglion of the cerebellum. 8. Converging fibres of the cerebellum. 9. Commissure of the cerebellum or mesocephalon. 10, 10. Par trigeminum. 11, 11. Crura of the cerebrum. 12. Transverse interlacement below the optic nerve. 13. One of the corpora albicantia. 14. Prolongation of the corpus albicans towards an anterior pillar of the fornix. 15. Optic nerve. 16. Optic nerve just before their decussation, turned back. 17. Band of transverse fibres of the optic nerve. 17. Reinforcement of optic nerve at the decussation. 19. Olfactory nerve. 20. Its internal root. 21. Its external ditto. 22. Its middle ditto. 23. Anterior commissure. 24. Internal part of the great superior ganglion or corpus striatum. 25. External part of ditto. 26. The bundles of the corpus striatum. 27. Anterior plate of the corpus callosum. 28. Convolution at the bottom of the fissura Sylvii. — (Gall.)

ations like the tree called the tree of life, whence their name of *arbor vitæ;* and one central.

A lateral view of the encephalon, sufficient having been removed to show the interior of the chorda oblongata. 1. Origin of the anterior pyramid, or great original band of the cerebrum. 2. The fibres of the anterior pyramid entered into the mosocephalon or great commissure of the cerebellum, and enlarged in their passage through it. 3. Crura, or great fibrous bands, of the cerebrum. 4. Their locus niger. 5. The corpus olivare or oval ganglion of the great chorda oblongata. 6. The thalamus opticus or great inferior ganglion of the cerebrum. 7, 7, 7. The corpus striatum or great superior ganglion of the cerebrum. 8. Corpus restiforme or original band of the cerebellum. 9. Corpus dentatum or ganglion of the cerebellum. — (Gall.)

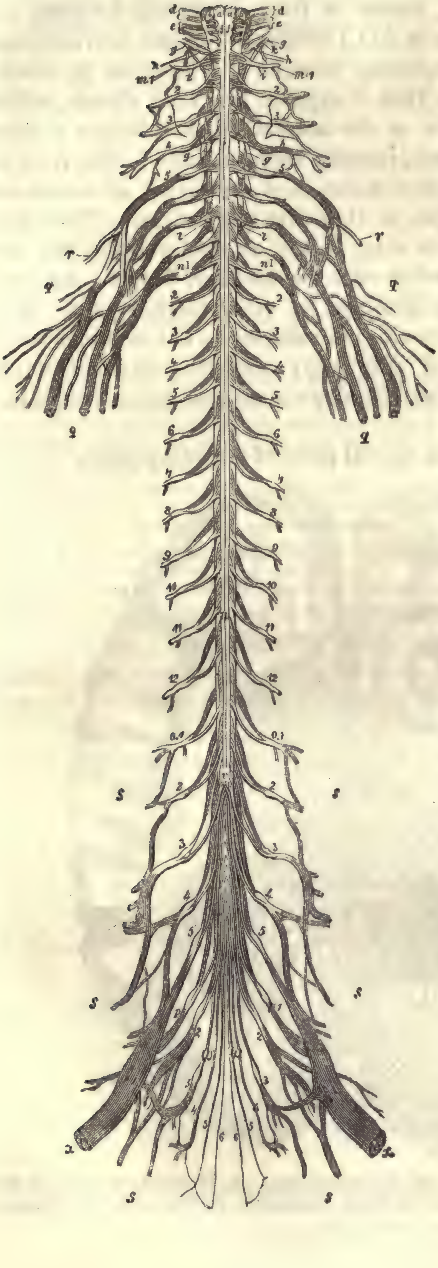
A smaller division of the brain, but the firmest, is the *Mesocephalon*, so named from its situation in the centre of the base, between the cerebrum and cerebellum, and over the spinal chord. (Cut, p. 311.) Two processes of the cerebrum, called *crura cerebri*, which contain some grey substance, whence the name *locus niger*,

The brain placed upon its base. The knife has passed through the middle of the great commissure or corpus callosum, 1, 1, 1, 1, as far as the infundibulum 2, situated below the anterior commissure 3, and as far as the corpora quadrigemina 4, 4, 4, 4. The two hemispheres are separated and unfolded. The posterior and superior parts of the nervous mass of the spine and brain are seen. The grooves 5, 5, are continuous with the lateral grooves 6, 6. 7. The central fissure. 8, 8. The space before the fundamental part or processus vermiformis of the cerebellum open; viz. the fourth ventrical: it is in connection, by means of a canal situated below the mass of communication called the valve of Vieussens 9, 9, and below 10, with the third ventricle or space, 11, 11, in the midst of the great inferior cerebral ganglion or thalamus opticus 12. The septum lucidum or common mass of communication and fornix are cut at 13, on each side, and entirely removed, in order to expose the great cerebral ganglion 12, 12, and 14, 14, 14, 14. On the side A, all the inner surface of the cerebellum is seen cut vertically through the centre. On the side B, the cerebellum has been removed by a horizontal cut from within outwards, and from before backwards, on a level with the white fibres 15, situated in the fourth cavity or ventricle, the fundamental part or vermiform process, and what is seen of the anterior surface of the side A. By a vertical cut in the direction from 13 to 16 (side A), the anterior and inner part of the hemisphere B has been removed, to show the diverging direction of the nervous band above the great inferior ganglion or thalamus opticus, the very fine fibres of grey substance, the great bands 17 in the middle, the direction of this mass of grey substance in the internal part 18 and in the external 19, and the proportional size of each of these divisions. 20, 20. Commencement of the pyramidal bundle of the cerebrum. 21. Corpus restiforme or original band of the cerebellum. 22. Fourth ventricle or the space before the fundamental part of the cerebellum. 23. Entrance of the pyramids below the pons or great original band of the cerebrum beneath the commissure of the cere-

bellum. 24. Median line of the cerebellum. 25. Middle of the nervous mass of the fundamental part of the cerebellum. 26. Ganglion or corpus rhomboideum of the cerebellum. 27, 27. Mesolobe. 28, 28. Valve of Vieussens or mass of connection of the primitive part of the cerebellum with the corpora quadrigemina. 29, 29. Pathetic nerves. 30. Commissure of the corpora quadrigemina. 31. Pineal gland. 32, 32. Superior band of connection of the pineal gland with the great inferior cerebral ganglion. 33. Soft or middle commissure of the inferior cerebral ganglion. 34, 34. Mammillary bodies. 35, 35. Transverse interlacement of the great cerebral bundle. 36, 36. Transverse interlacement below the optic nerve. 37, 37. Optic thalamus or great inferior cerebral ganglion. 38, 38. Transverse interlacement of the nervous bands of the middle lobes. 39, 39. Transverse interlacements of the great superior cerebral ganglion. 40, 40. Fold of the corpus callosum or mass of union of the inferior convolutions of the anterior lobe. — (Gall.)

and two of the cerebellum, called *crura cerebelli*, appear to run to it. The corpora quadrigemina are a part of its superior, or, as it lies obliquely, posterior, portion ; and it, with its continuation —the chorda oblongata, furnishes the anterior wall of the fourth ventricle. This cavity is irregularly quadrilateral, and runs obliquely from the aquæductus Sylvii or iter a tertio ad quartum ventriculum, under the valve of Vieussens and processus ad testes, downwards upon the back of the chorda oblongata, and before the vermiform process of the cerebellum. On the floor of it, or, as from the oblique position of the parts we might say, the back of the chorda oblongata, is a groove which ends in a triangular depression called *calamus scriptorius*.

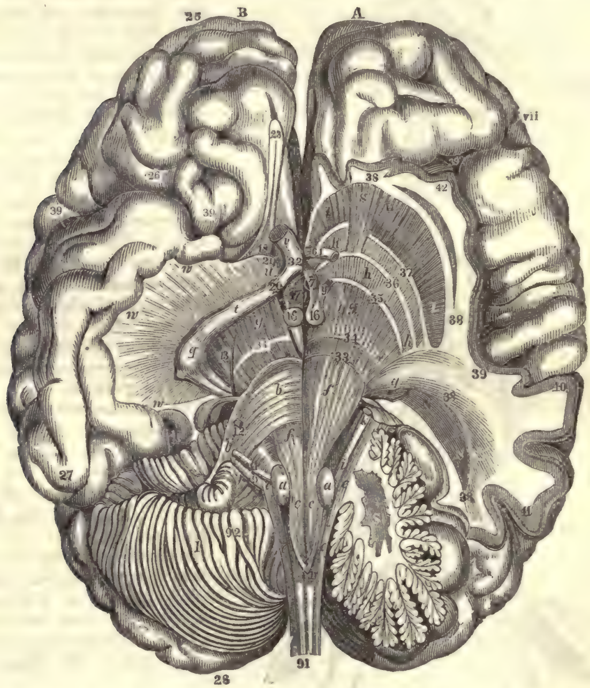
The mesocephalon, thus appearing formed of prolongations — two from the cerebrum, and two from the cerebellum — is itself apparently prolonged into a short bulbous chord, termed *chorda oblongata*, which lies upon the basilar process of the occipital bone. (Cut, p. 304.) On its anterior or lower surface (for it, like the mesocephalon, lies obliquely) are seen four elevations ; the two outer called *corpora olivaria*, the two inner *corpora pyramidalia*, or *c. p. anteriora*, or *anterior pyramids*. (Cut, p. 311.) On its lateral parts are two oblong prominences, called *corpora restiformia :* and on its posterior portion two others, called *corpora pyramidalia posteriora* or *posterior pyramids*. (Cut, p. 313.) This chord apparently prolonged becomes the *chorda spinalis*, which runs in the vertebral canal, from the foramen occipitale to the first or second lumbar vertebra, larger and smaller in various parts of its course : smaller at first than the bulbous chorda oblongata, it swells in the middle of the cervical region, diminishes at the end of this, swells again at the upper part of the loins, and diminishes through the rest of its course, till it ends in an oval



a, a, Anterior corpora pyramidalia of the chorda oblongata. *b, b,* Corpora olivaria. *c, c,* Corpora restiformia. *d,* Glosso-pharyngeal nerve. *e,* Pneumonogastric. *f,* Hypo-glossal. *g,* Accessory nerve. *h,* Posterior root of the first cervical pair. *i,* Anterior root. The posterior root in this, as in many subjects, gives a twig, *k,* to the accessory, and crosses before it to reach the anterior root. In this instance, not only is there a communication between the accessory and the posterior root of the first pair, but the accessory actually begins from a twig uniting the posterior roots together. *l,* First root of the accessory. *m,* 1, The first cervical pair, formed of its anterior and posterior root. *m,* 2, to *m,* 8, are the successive cervical nerves, with their two roots. *n,* 1, to *n,* 12, The successive dorsal ditto. *o,* 1, to *o,* 5, The successive lumbar. *p,* 1, to *p,* 6, The successive sacral. *q, q, q, q,* The cervical plexus, formed by the eight cervical and first dorsal nerves; and furnishing, among other nerves, *r,* The phrenic. *s, s, s, s,* The lumbo-sacral plexus, consisting of nerves furnished by the lumbar and sacral nerves. *t,* The cervical enlargement of the spinal chord. *u,* The lumbar enlargement. *v,* Its termination, where it splits into many nerves, called altogether, *w, w,* The cauda equina. *x,* The last nerve of the lumbro-sacral plexus, or sciatic. — (Dr. Manec.)

bulbous extremity. A fissure in front, beginning between the anterior pyramids, (Cut, p. 311.) divides it into two lateral halves. Another, less deep, beginning between the posterior pyramids, divides it posteriorly. Thus it appears two long chords, united in their middle line; for at the bottom of each fissure a layer of white substance is seen, running longitudinally in the form of two bands at the posterior fissure, and consisting of transverse filaments at the anterior, as Gall first pointed out. Two faint grooves are seen at each side, in the cervical portion; the one near the posterior, the other near the anterior, fissure. Its consistence is generally less than that of other nervous parts. It is composed chiefly of white fibrous substance; but in the midst of this is seen a fine layer of grey pulpy substance, very irregular in shape,—not solid, but, as Mr. Mayo mentions, really a capsule.

We will now trace the several parts of the encephalon.



B, Right side of the base of the encephalon. I, Hemisphere entire of the cerebellum. The primitive band or corpus restiforme *e e* of the cerebellum plunges

between the facial nerve, 11, and the acoustic nerve, 9. The trigeminus or fifth is still covered entirely by the transverse fibres of the cerebellum. The olivary ganglion, *a*, is prolonged below the transverse fibres *b* of the cerebellum; one part of the transverse fibres of the cerebellum is removed to show the continuation of the pyramidal band 1, *c*, *c*, which begins to diverge and be reinforced. Outside the optic nerve *q*, *t*, *v* is seen the expansion of the nervous bands, in the inferior convolutions *w*, *w*, *w* of the middle lobe 26, 27.

A, Left side of the base. A verticle cut of the cerebellum, directed through the entrance of its original bundle *e e*, and through the middle of its ganglion *s*, in the direction 92, 28, B, to show the reinforcement of the original bundle in the ganglion, and the ramifications and subdivisions of the nervous chords. All the transverse fibres of the cerebellum which cover the trigeminus *k*, *i*, and the prolongation *f* of the pyramidal bundle 1, *c*, *c*, are removed. The prolongation of the olivary ganglions *a*, *a* is still covered by the transverse fibres. The optic nerve is removed from the great fibrous bundle *g*, and cut at *v*, *q*. The pyramidal bundle is seen prolonged from the decussation 1, to the transverse interlacement 35, below the optic nerves. The grey mass 17 has been removed by scraping, to show the two cords of the mammillary bodies 16, 16; the one *y*, towards the transverse interlacement 35, the other, 7, towards the common mass of communication or fornix. The nervous fibres which spread out in the convolutions of the middle lobe, and contribute to its functions, are cut at *h*, *h*, *h* between 35 and 37, on a level with the anterior commissure; and the middle lobe is entirely removed. The mass of grey substance of the great superior ganglion of the brain, and a part of the convolutions situated below the great fissure, between the middle and anterior lobes, are cut in the same direction. We thus see how this great mass is divided by the nervous bundles S into an inner part *l*, and an outer part, L L; how the finest fibres are implanted in the grey substance; how the convolutions 40, 41 are formed by the posterior chords of the great fibrous bundle or crus placed before *q*, and what are the depth and length of the great fissure 39, 39 between the anterior and middle lobes. By the removal of the middle lobe, the posterior edge of the great cerebral cavity N N becomes visible. This cavity is prolonged inwards and forwards below the great fibrous bundle or crus *g*. Between 40 and vii. are seen the convolutions situated above the fissura Sylvii between the anterior and middle lobes. The anterior lobe is but slightly cut.

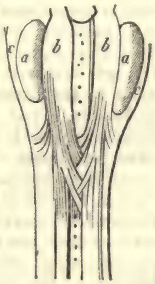
21. Internal root of the olfactory nerve. 18. Its external root. 23. Its bulb. 25, 26. Anterior lobe of the cerebrum. 27. Its middle lobe. 28. Its posterior lobe. 20. Optic nerve. 32. Decussation of the optic nerves. *v*. Optic nerve after its decussation. 33. Transverse interlacement of the upper edge of the great commissure of the cerebellum. 34, 34. Transverse interlacement of the great fibrous bundle. 36. Transverse interlacement of the nervous bundles of the middle lobe. 37. Tranverse interlacement of the great superior cerebral ganglion. 38, 38, 38, 38. Situation of the tissue of the two orders of nervous filaments. 13. Pathetic nerve. *b*, *b*. Pons Varolii. 91. Central fissure of the posterior part of the spinal chord. 61. Anterior commissure of the cerebrum. — (Gall.)

According to Gall [c], many primitive bundles of nervous fibres give origin to the cerebrum and cerebellum. The anterior and posterior corpora pyramidalia, bands proceeding immediately from the corpora olivaria, longitudinal bands which contribute to form the fourth ventricle, and many others concealed in the chorda oblongata, to the cerebrum; the corpora restiformia to the cerebellum.

The bands arising from the anterior pyramids are the only ones

[c] l. c. vol. i. 270. sqq.

which decussate; the two halves of the cerebrum, the cerebellum and spinal chord, being united by commissures. MM. Magendie and Desmoulins, just as Prochaska, Barthez, Sabatier, Boyer, Dumas, Bichat, and Chaussier did before them, deny the decussation; but it was known of old, as Gall remarks in his demonstration of it, and cannot be disputed. The following, from Mr.



a, Corpora olivaria; *b*, Corpora pyramidalia, seen to discussate at their lowest part, where are three sets of ascending fibres on each half—one turning from behind *c*, the corpora restiformia, another running straight, and the third decussating. This writer, however, speaks of them not as ascending, but descending.

Mayo, shows it well. This forms an exception to the rule observed in every other part of the cranial nervous organs, except the optic nerves and the fibres which run from the genitals to the cerebellum, of the nervous fibres, destined to each side of the body, running on the same side of the brain; and we hence explain why injuries of one side of the brain, causing paralysis, generally influence the opposite side of the body.[d] The spinal chord has no decussation, whence injuries of one side of it influence the corresponding half of the body. Decussation has not been discovered in the cerebellum; and vivisectors say that an injury of a cerebellic hemisphere affects the same side; but Gall found that extirpation of a testicle caused the opposite lobe of the cerebellum to shrink.[e]

After their decussation, the bands of the anterior corpora pyramidalia ascend on the ANTERIOR part of the chorda oblongata (called by Gall the *grand renflement*), enlarging as they proceed. As soon as they enter among the transverse fibres of the mesocephalon, called by Gall *the great commissure of the cerebellum*, they divide into many bundles, which are imbedded in a large quantity of pulpy substance, from which proceed many fibres,

[d] I have never known an exception to this; but exceptions are recorded, and probably some difference of situation is the reason of the difference of effect.

[e] l. c. vol. iii. p. 112. sqq. *Sur les Fonctions du Cerveau*, t. iii. p. 291. sqq. Dr. Vimont has repeated Gall's experiments with the same results. *Traité de Phrénologie humaine et comparée*, par J. Vimont, M.D. 2 vols. 4to. with an atlas of 120 plates. Paris, 1832—5. vol. ii. p. 233.

joining and augmenting them while passing through this ganglion, for such it really is ; so that they come out increased enough to constitute, on the anterior and outer part, at least two thirds of the crura cerebri, or, as Gall terms them, *the great fibrous bundles of the hemispheres.* They contain a large quantity of pulpy substance, and enlarge the most at their superior extremity, where the optic nerve turns round them. Their filaments and bundles leave the great fibrous mass at the anterior or outer side of the optic nerve, and, diverging more and more, form the lower, anterior, and outer convolutions of the anterior and middle lobes, which, with the anterior and outer part of the crura and ganglion in the mesocephalon, are always in direct proportion to the pyramids. (Cut, p. 311.)

The corpora olivaria are true ganglia. A large bundle proceeds from each, and ascends with the POSTERIOR bundles of the chorda oblongata among the transverse fibres of the mesocephalon, like the bundles of the pyramids, but acquiring fewer additional fibres than these from among the pulpy matter. On leaving the mesocephalon, they form the posterior and inner part of the crura cerebri. They acquire their greatest increase on entering the crura, on account of the large quantity of pulpy substance which is there, called *locus niger*, which, with the fibres it produces, forms the two thalami optici, that are here pretty firm ganglia, and are called *the great inferior cerebral ganglia* by Gall. The bundles, on leaving the superior part of these ganglia, reunite into fibres less diverging, and then traverse two other ganglia — the corpora striata, called by Gall *the external masses of the pulpy substance of the great superior cerebral ganglion.* Here they acquire another increase, sufficient to enable them to form the posterior lobes and all the superior convolutions of the anterior and middle lobes (Cut, p. 312.), which are always in direct proportion to the thalami.

All these fibres of the brain (Cut, p. 312.) are styled by Gall *diverging*, departing, or apparatus of formation. But those of the two sides, that are united by transverse fibres or commissures, are styled by Gall *converging* or entering fibres. The mesolobe is the great commissure of the superior convolutions of the hemispheres. The inferior convolutions of the anterior lobes are united by what was called the anterior fold of the mesolobe, — by the anterior portion of it, which was considered to bend down and thus form the anterior extremity of the lateral ventricles, afterwards

forming their floor by running on backwards, just as before bending down it had formed their ceiling. This pretended anterior fold is consequently termed by Gall *the mass of the union of the inferior convolutions of the anterior lobes.* The fornix is the commissure of the posterior convolutions of the middle and of all of the posterior lobe, and is called by Gall *the mass of the general communication of the brain.* The lyre is the assemblage of the filaments of union in the fornix. The pretended posterior fold of the mesolobe is the commissure of the posterior internal convolutions of the middle lobe. The anterior convolutions of the middle lobe, and some situated at the bottom of the *great fissure of Sylvius*, called by Gall *the great fissure between the anterior and middle lobes of the cerebrum*, give rise, by their union, to what is called *the anterior commissure of the lateral ventricles*, but by Gall *the union of the anterior convolutions of the middle lobe.* The *posterior commissure* of the lateral ventricles cannot be traced to the convolutions, but only just into the thalami optici, and is therefore named by Gall *the posterior commissure of the great inferior cerebral ganglion.* The middle commissure, for the same reason, and on account of its softness, is called by him *the soft union of the great inferior cerebral ganglion.* (Cut, p. 313. 316.) Each of these points of union is proportionate to the parts which it unites. Gall considers the origin of the converging fibres to be in the superficial pulpy substance.

The converging fibres of all these commissures, after lining the interior of the two lateral ventricles, or *great cavities of the cerebrum*, as Gall styles them, while he terms the third ventricle *the space between the great inferior cerebral ganglia*, interlace with the *diverging* fibres, and thus form a true tissue. (Cut, p. 313. No. 35, 36. 38, 39.; p. 316. No. 33, 34. 36, 37.)

The diverging fibres are then prolonged in the form of a fibrous expansion.

If the ventricles are opened, and their walls gently expanded with the hand, or if fluids collect in them, as in hydrocephalus, the tissue of diverging and converging fibres is at length lacerated. After this, the expanding force acts upon merely diverging fibres, and all the convolutions disappear; the brain becoming expanded into a smooth bag. A convolution is thus proved to be two fibrous layers, placed side by side, and very slightly united: therefore, if air or water is impelled against the centre of a

convolution cut transversely, it opens this from its base to its summit.[f]

A convolution. The centre (*a*) of the white substance is seen opened by the impulse of air.

Many fibres, especially those at the sides, are short; while others are longer, and this the more central they are. Hence the prolongations and depressions of the surface of the cerebrum—or, in other words, the convolutions. The parts most developed have the fewest convolutions; and, in hypertrophy of the brain, the surface is also more regular and smooth, the shorter fibres approaching in length to the longer. The convolutions are seldom quite vertical, and their white substance is thicker at their lower parts, since there both the shorter and the longer fibres exist.

All the fibres are covered by cineritious pulpy substance at their extremities.

The origin of the cerebellum is in the *corpora restiformia*, according to Gall.[g] They increase as they ascend; and, entering the cerebellum, penetrate to a mass of grey substance of a somewhat rhomboidal form and with serrated edges, whence it is styled *corpus rhomboideum* or *dentatum*. It is considered by Gall

[f] Gall, from observing the mind of hydrocephalic patients to be little or not at all impaired, was certain that Walter, Ackerman, and numerous others, were wrong, who maintained that the brain was destroyed in the disease. Finding a female, 54 years of age, with her head greatly enlarged, he entirely supported her, as he informed me, till she died, in order to prove the correctness of his opinion. He examined her brain, and was thus led to discover the true nature of the convolutions, and the operation of the distending fluid in hydrocephalus. Mr. Chenevix, Dr. Spurzheim's friend, suppresses this (*British and Foreign Quarterly*, 1830), and says that a fortunate accident occasioned the discovery (p. 10.). His article contains other instances of inaccuracy and injustice towards Gall; but received Dr. Spurzheim's sanction. By this discovery alone, Gall proved that those, who still obstinately spoke of the brain as *pulp*, were wrong. Pulp would be washed or blown away at the centre, and every where else, by the impulse of air or water, and would not separate into two regular layers. Yet I recollect that in Edinburgh, in 1809, when I was studying, his anatomy and his assertion of the fibrous structure of the brain were ridiculed as too absurd.

[g] *Anat. et Phys.*, vol. i. p. 249. sqq.

as intended to increase the formative fibres of the cerebellum, and therefore he terms it the *ganglion of the cerebellum*. (Cut, p. 311. No. 7*.; p. 312. No. 9.) One of the principal bands which proceed from this advances towards the median line, and with its fellow becomes a long rounded eminence, or ridge, rising from before backwards, and usually called *the vermiform process*, but by Gall *the fundamental part of the cerebellum*, because it is always found in animals which have a cerebellum. (Cut, p. 313. No. 8.) The other bands from the ganglion proceed upwards, downwards, backwards, and outwards, disposed in thin horizontal layers; those which are nearest the middle being the longest, and those nearest the spot where the original bundles enter the ganglia the shortest. Their extremity distant from the middle is covered with cineritious pulpy substance. A vertical cut exhibits the white layers as branches and twigs, each being surrounded by cineritious substance; the twigs so surrounded resemble leaflets; and the whole is known by the name of arbor vitæ. (Cut, p. 312, 313. 316.)

Besides these *diverging* fibres, there are, as in the cerebrum, converging fibres, having no immediate connection with the primitive bundle, with the chorda oblongata, or with the ganglion. These arise from the pulpy substance, and proceed in different directions among the diverging fibres towards the external anterior part, where those from each side, under the name of crura cerebelli, unite together and form the mesocephalon, or, more properly, the large commissure of the cerebellum. (Cut, p. 304. No. 13.; p. 311. No. 9.; p. 313. No. 27.; p. 316. *b*.) The size of this is in direct proportion to the size of the hemispheres of the cerebellum, just as the corpus restiforme, ganglion, and cerebellum, are all proportionate to each other. Another cerebellic commissure exists at the vermiform process, by means of the soft delicate layers of transverse fibres of its superior and inferior part. A layer of fibres, under the name, according to Reil, of inferior medullary veil, or commonly of valve of Vieussens and processus a cerebello ad testes, or, according to Gall, of *mass of connection between the primitive part of the cerebellum and the corpora quadrigemina*, establishes a commissure between the cerebellum and the corpora quadrigemina: and another layer, termed by Reil the superior medullary veil, establishes a commissure between the lower portion of the fundamental part or vermiform process and the posterior pyramidal bodies of the chorda oblongata. (Cut, p. 313.) The fourth ventricle is a mere space

between the chorda oblongata and the cerebellum. (Cut, p. 313. No. 8, 9, 10.) Gall terms it the space placed before the fundamental part of the cerebellum, just as he terms the third ventricle the space between the great inferior cerebral ganglions; and the lateral ventricles he styles the great cavities of the cerebrum. Dr. Macartney has lately declared that the sides of the encephalic cavities are so closely applied to each other that no cavity really exists; so that there is merely an extension of internal surface.[h]

The encephalon communicates with the rest of the body by the spinal chord and other chords termed *nerves*. These appear proceeding from its base and from the spinal chord. If we inspect the base of the brain (see Cut, p. 304.), we observe, besides the cerebrum and cerebellum with their lobes, the mesocephalon and chorda oblongata, the corpora albicantia, pons Tarini, tuber cinereum, infundibulum, and pituitary gland — the four latter of which are, like the parts in the ventricles, most absurdly named, and the five latter of which are masses of pulpy substance — eleven pairs of nerves: — the *glosso-pharyngeal*, for taste only; the *olfactory*, for smell only; *optic*, for sight only; *acoustic*, for hearing only; three conveying volition to the muscles of the eye, the *common motors*, *trochleare* or *pathetic* or *internal motor*, and *abducent* or *external motor;* the *lingual*, conveying volition to the muscles of the tongue; the *facial*, conveying volition to some muscles of the face; the *vagum*, or, according to Chaussier, pneumo-gastric, but correctly *pneumono-gastric*[i], — a pair of sense and motion, communicating between the lungs, larynx, trachea, and stomach, &c., and the brain; and the *trigeminum*, which also is double, and furnishes many nerves giving common sensibility to the face and head at large, and conveys the will to the muscles of the lower jaw.[k]

[h] *Report of the Third Meeting of the British Scientific Association*, p. 453.

[i] Such words, compounded of two Greek or Latin nouns, are made with the dative of the first, its last syllable being generally made to end in *o*. The genitive of *πνεύμων* is *πνεύμονος*, and the dative *πνεύμονι*. See my paper on the Medicinal Properties of Creosote, in the 19th vol. of the *Transactions of the Royal Med. and Chir. Society*, p. 11. sqq.

[k] In old language, the glosso-pharyngeal; the first; second; portio mollis of the seventh; the third, fourth or pathetic, and sixth; ninth; portio dura of the seventh; the eighth, of which the glosso-pharyngeal was considered a part; and the fifth, or mixed pair, as Gall called it from being satisfied of its mixed functions.

The olfactory, optic, and common and internal motors of the eye, arise from the cerebrum or mesocephalon; the rest from the chorda oblongata. From the chorda spinalis, thirty-one pairs of nerves, double in substance and function, like the trigeminum, proceed on each side, by an anterior and a posterior root; — eight pairs in the neck — the first above the first cervical vertebra, the last below the last cervical vertebra; twelve in the back; and five in the loins, — the last below the last lumbar vertebra. The anterior root of these double nerves is smaller than the posterior, and each begins by many filaments, which unite in their passage out. The posterior root forms a ganglion, and the nerve externally to this unites with the anterior nerve.

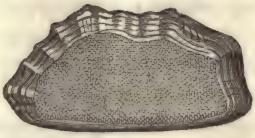
The five pairs of the lumbar portion, proceed, enclosed in membrane, together with five or six other pairs, from the bulbous extremity of the chord, and pass through the foramina of the sacrum. This splitting of the chord is termed the *chorda equina*. Besides these, a pair arises at about the seventh or eighth cervical pair, called *accessory*, running up into the cranium through the foramen magnum, and coming in contact with the pneumonogastric nerve; and it passes out again through the foramen lacerum.

Many nerves unite: for instance, twigs of the portio dura with twigs of all the branches of the trigeminum; and twigs of the ninth with the lingual branch of the trigeminum. Many nerves unite to separate again, forming what are termed *plexuses;* and the nerves running into and from a plexus may be different in number. (Cut, p. 315.) On some nerves we observe nodules of various shapes, called *ganglions;* and sometimes more than one nerve have the same ganglion. We have seen that Gall applies the word ganglion to masses of nervous substance also in the encephalon and spinal chord; and other anatomists, in a similar manner, apply it to the enlargements of the fifth cerebral nerve and of the posterior spinal nerves.

Nerves are collections of white filaments contained in delicate membranes, and united into fibres like those of the brain, and all invested with another membrane, called *neurilema*, which again is enclosed in a firm white membrane. M. Raspail has lately examined them, and finds them to be aggregations of solid cylinders, each invested, like muscular fibrils, with a fine membrane, and the whole with a common covering to form a trunk.[1] He declares that no tube exists in them, as many have asserted. A

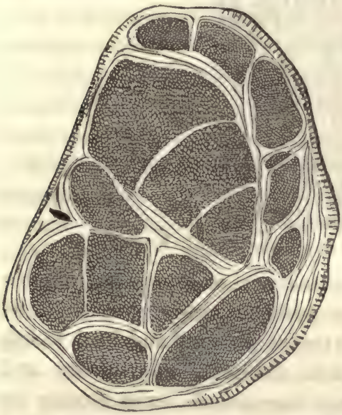
[1] *Nouveau Système,* § 513. sqq.

thin transverse section of a branch of a ganglionic nerve ex-



Slice of a branch of a ganglionic nerve. — (M. Raspail.)

hibits a single chord; but a similar section of the median of the arm exhibits several, every chord having its own membrane, as



Slice of the median nerve of the arm: the cut ends of the fibrils are seen, with the covering of every bundle, and of the whole. The single spot represents a blood-vessel. — (M. Raspail.)

well as the whole one in common; and their number is greater, the further from the head the examination is made.

A longitudinal view presented the filaments with a granulated appearance, like the orifices of tubes; but this was probably the effect of the refraction of light, and it occurred when other textures were examined in the same way. (See first cut overleaf.) Each cylinder of a human nerve is said by M. Raspail to be about ·00787 of an inch in diameter.[m]

Though the fibres are parallel, their filaments continually unite, so that a nerve appears more or less reticular.

A plexus is the same arrangement on a large scale.[n]

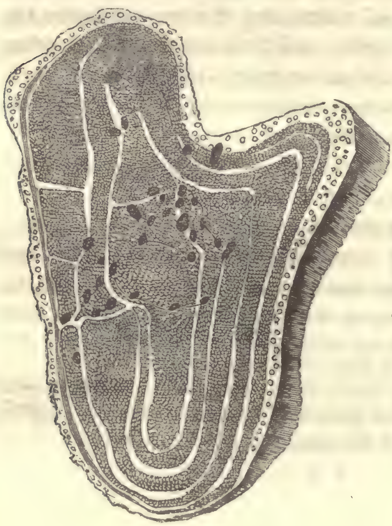
Ganglions consist, like the encephalon and spinal chord, and

[m] Professor Ehrenberg says that the olfactory and optic nerves, and the branches of the sympathetic, are entirely composed of granulated or knotted fibres; while nerves of motion and the regular spinal nerves are cylindrical and tubular, and continuations of knotted fibres of the brain now become cylindrical.

[n] Dr. Macartney asserts, indeed, that in all plexuses a complete mingling of the substance of all the nerves takes place, and that there no less is a mingling of the roots of the spinal nerves with the spinal chord. (l. c. p. 451.)

Longitudinal view of the fibrils of a nerve. —(M. Raspail.)

the swellings at the roots of the nerves of sense, called also ganglia, of white fibrous substance, and of a pulpy, greyish, reddish, or whitish substance in which this is plunged and from which it is easily distinguished. The white filaments anastomose and interlace or mingle most freely, and membranes exist similar to those of nerves, within them and without. M. Raspail represents a ganglion like the median nerve, only that the separate portions half enclose each other.



Slice of a ganglion of the sympathetic nerve. The nervous trunks are only half enclosed in each other, but all in a common covering. The black spots represent blood-vessels. —(M. Raspail.)

Besides the ganglia of the encephalon and of encephalic and spinal nerves at their origin, there are, on each side, several ganglia in the head;—the ophthalmic or lenticular, the spheno-palatine or Meckel's, and the cavernous, the otic, and sub-maxillary; there are three cervical; twelve dorsal; five lumbar; and five or six sacral; one at the heart, called cardiac; and two in the abdomen, called semilunar. Branches connect them with the encephalic and spinal nerves. Single branches run longitudinally between them all, connecting their whole series; and the lines unite in a single ganglion on the os coccygis. Old anatomists gave the whole the name of sympathetic or intercostal nerve, and supposed it to arise from the encephalo-spinal nerves.[o] The ganglionic nerves are less firm than the encephalo-spinal, and of a less clear white.

We must not forget that every part of the nervous system throughout the body is directly connected with others, and indirectly with all the rest, just as is every blood-vessel in regard to its system.

Nerves subdivide and soften till they are lost, with the exception of the optic, which expands into a membrane called retina, and of the coalition of nerves. The diameters of branches are said usually to exceed that of a trunk.

I have used the words *prolongations, arise*, &c., but merely for the purpose of ocular description; since Gall has shown that the nerves and spinal chord do not arise from the brain, but only communicate with it; nor the spinal nerves from the spinal chord: for, when the brain is absent, the fœtus may equally possess encephalic nerves and spinal chord[p]; and, when the chord is absent, the fœtus may equally possess spinal nerves; and the brain and spinal chord, and the brain and encephalic nerves, are in no proportion to each other in the various species of the animal kingdom, nor the spinal nerves to the spinal chord, nor does the latter diminish as the nerves go off.

The idea of the nerves proceeding from the brain is as unfounded as that of the arteries proceeding from the heart, or one portion of an extremity from another. Fœtuses are seen with an arterial system, and no heart; others born with no arms, but

[o] Writers say cerebro-spinal. But, if cerebrum is not allowed its classical meaning — the whole cranial nervous mass — as well as its scientific application to a portion only, the term cerebro-spinal must be replaced by encephalo-spinal.

[p] Gall, 4to. t. ii. p. 77. sqq.; 8vo. vol. i. sect. ii. For spinal nerves without chord, see *Hist. de l' Acad. des Sciences,* 1746, p. 42.

fingers at the shoulders. Independently of contrary arguments, we may demand proofs of the opinion: none are given; and it has, no doubt, been derived from the shooting of vegetables. Gall's opinion is now universal. Yet, when he wrote, he found no recent modern writer doubt that the spinal chord was a prolongation of the encephalon.[q]

When I published my last edition, Gall's anatomy was so little known, and his mode of dissecting the brain by tracing its constituent parts so disregarded, that I felt it right to express my wonder, as one of his disciples, M. Barbeguière, did thirty years ago in Berlin[r], that, while students were not instructed to dissect limbs and trunks by slices, as we cut brawn, they should be taught no other mode of examining the brain, and thus be left in ignorance of its true structure. But now his anatomical discoveries are referred to in every good book upon anatomy; and are given at full length in Dr. Cloquet's *Manuel d' Anatomie descriptive*, and the excellent *Elements of Anatomy* by Dr. Quain; and his mode of dissecting the brain is taught in all the best schools.[s]

[q] "This was the opinion of MM. Sabatier, Portal, Chaussier, Boyer, Cuvier, Fodéré, Dumas, Ackerman, Walter, &c." (*Anat. et Physiol.*, vol. i. p. 50.) just as of the ancients, and of other moderns, except Bartholin and Vieussens; of whom the former began to doubt, and the latter, indeed, expressed himself decidedly; but then in his descriptions and figures Vieussens still represented the brain as the origin of all the nerves, — an inconsistency committed by Soemmerring, who, while he regards the spinal chord as self-existent, declares it is produced by the mixture of the medulla of the cerebrum and cerebellum. Haller, Soemmerring, Blumenbach, derived the nerves from the brain and spinal chord; Prochaska, Reil, Bichat, Cuvier, even the ganglions also from the latter; and all continued to regard it as a prolongation of the encephalon. The French commissioners gave way; but Ackerman and Walter persisted! (l. c. vol. i. p. 49. sqq.

[r] *Exposition de la Doctrine de Gall sur le Cerveau et le Crâne*, par Dr. C. H. E. Bischoff; traduit de la seconde édition de l'Allemand, par G. Barbeguière. Berlin, 1806. "Is it not the height of folly to pretend to demonstrate the brain accurately by destroying it in slices?" (p. 19.)

[s] We may see in a report of Cuvier's, upon the experiments of M. Fleurens, after the fall of Napoleon, his admission of many of Gall's discoveries, which, in order to please Napoleon, who was jealous of the German, from being vexed with the honours paid by the Institute to another foreigner, — our countryman Sir Humphry Davy, he had previously doubted, or absolutely denied (having been favourable to Gall's views till he suddenly learned Napoleon's feelings) in a report presented by him and others upon Gall's anatomical discoveries to the French Institute, in 1808; — "A report," says Gall, "which will always be one of the most valuable proofs of the backward state of the anatomical and

There are great varieties in the absolute and relative amount of the several portions of the nervous system. But the brain of

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physiological knowledge of the nervous system at that time, and how much science owes me in this respect." (*Sur les Fonctions du Cerveau*, t. vi. p. 318.) Even in this report, Cuvier had been obliged to confess that "the most accredited method of the schools, and that usually recommended in books of anatomy, is to take away successive slices of the brain, and observe the appearances offered by each. This is the easiest in practice for demonstration, but it is the most difficult for the imagination. The true relation of parts, which are always seen cut across, escape not only the pupil, but the master himself." Yet, rather than give Gall the due credit of unfolding the brain from the chorda oblongata, the Committee of the Institute pretended that Varolius and Vieussens had, two centuries before, done the same thing; whereas Vieussens dissected the brain from the centrum ovale, and he is declared by the Committee to have practised the same mode of dissection that Varolius employed. Varolius, on the contrary, began his dissection at the base, yet not in order to trace the parts from the base, through the brain, but simply, he says, because the brain compressed the several organs at the base, against the skull, especially in the dead body, and rendered the ordinary mode of dissecting from above inconvenient. He had so false an idea of the anatomy of the brain, that he conceived the crura cerebri and cerebelli were shoots from the respective parts, and produced the spinal chord: while, however, he also declares the spinal chord to *be formed from the cerebrum*, between the hemispheres and the pons! In truth, our countryman, Dr. Willis, who lived a century and a half ago (*Cerebri Anatome*), was the first who objected to slicing, and dissected the brain from the base: but by base he understood the corpora striata and the thalami; and from these he both ascended and descended to the chorda oblongata. (*Rapport des Commissaires de l'Institut de France*, in Gall's *Recherches sur le Système Nerveux en général, et sur le Cerveau en particulier.*

The *Edinburgh Review*, which we shall see viewed the whole doctrines of Gall, "anatomical, physiological, and physiognomical," as a piece of thorough quackery from beginning to end, in June, 1815, did him justice, like Cuvier, lately, in a most remarkable manner, but without the generosity of mentioning his name. (No. xciv. 1828.) "Even within our own time," it now says, "although many great anatomists devoted themselves almost exclusively to dissecting the brain, this organ used to be demonstrated by the greater number of teachers in a manner which, however invariable, was assuredly not particularly useful. It was so mechanically cut down upon, as to constitute a sort of exhibition worth nothing. The teacher and the pupil were equally dissatisfied with the performance, and the former probably the most. The latter soon gave up the painful attempt to draw any kind of deduction from what he witnessed, and disposed of the difficulty as he best could, when he had to render an account of what he had seen. Up to this day, our memory is pained by the recollection of the barbarous names and regular sections of what was then the dullest part of anatomical study, which, although often repeated, left no trace but of its obscurity or absurdity. Here an oval space of

an adult, probably between 20 and 60 years of age[t], is said to weigh, on the average, between 40 and 50 ounces; the

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white colour, and there a line of grey, or one of red, were displayed: here a cineritious, there a medullary, mass: here a fraction white without, grey within; there a fraction white within, and grey without: here a gland pituitary, there a gland like grains of sand: here a ventricle, and there a cul de sac with endless fibres, and lines, and globules, and simple marks with appellations no less fanciful than devoid of meaning." These are just Gall's views, for which he was loaded with opprobrium. *Anat. et Physiol.*, vol. i. p. 287. sq. 285.

Loder, who not only had attended Gall's lectures at Halle, but dissected nine human and thirteen brute brains with him, adds, after specifying Gall's anatomical discoveries, "These discoveries alone would be sufficient to immortalise Gall's name: they are the most important which have been made in anatomy since the discovery of the absorbents. The discovery of the unfolding of the brain is admirable." "I am ashamed and indignant with myself for having, with others, been slicing hundreds of brains, like cheese: *I* never perceived the forest for the multitude of the trees." "I say, with Reil, that I have found more than I thought one man could discover in the course of his life." *

"Reil," said Professor Bischoff, above thirty years ago, "who, as a profound anatomist and judicious physiologist, requires not my praise, rising superior to all the littleness of vanity, has declared that he found more in Gall's dissections of the brain than he thought *any* man could have discovered in *his* whole life." *Exposition*, just quoted, p. xxvi.

Such is the judgment of Reil on what Mr. Mayo calls Gall's "popular and showy anatomy," dependent for its correctness, when it is correct, "rather to bold and fortunate conjecture, than to cautious and philosophical research;" amounting to "little more than an expansion of the views of Willis," and destitute of the force of "demonstration which belongs to the researches of" Reil — their "rival." Gall, so far from regarding Reil as a rival, thus speaks of him: — "With what readiness would the nervous system, this noble part of anatomy and physiology, the knowledge of which has so long made such small progress, have been restored to its dignity, if, in every country, men like Reil, animated with the love of truth, and endowed with a spirit of profound observation, had followed his example! We are proud that the discoveries made by this able naturalist in the cerebellum, by following a totally different course from ours, agree so perfectly with ours." (*Anat. et Physiol.*, p. 250.) In truth, Gall was too good towards Reil; for, after Gall's report to the French Institute, Reil,

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[t] Dr. Sims has just published, in the 19th vol. of the *Trans. of the Royal Med.-Chir. Society*, the most extensive averages of the weight of the brain. His average weight of the adult brain, between 20 and 60 years of age, is from rather above 44 to rather above 46 ounces.

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* Bischoff, l. c. p. xxix. Also Gall, 4to. vol. iv. p. 378. sqq.; 8vo. t. vi. p. 493. In this sixth volume will be found copious answers to Tiedemann, Rudolphi, Serres, &c., and a refutation of many of their anatomical assertions.

spinal chord about an ounce and a half; and the corresponding nerves, could they be collected to their minutest ramification,

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from whom Gall was said by Dr. Gordon and Mr. Mayo to have borrowed, but from whom he could have learned nothing, because Reil had not published at the time of Gall's discoveries, promulgated, in his *Archives*, views similar to those of Gall, without, indeed, claiming them as his own, but without ascribing them to Gall or any one. He also gave the parts different names — such as wings, mountains, teeth, lobules — agreeable to none but mechanical dissectors, who, like Dr. Gordon, as Dr. Spurzheim remarks, consider the anatomy of the brain unnecessary to physiological and pathological views.

Gall demonstrated the Brain to Reil, in the summer of 1805, privately, and so much pleased him that he gave Gall some of his drawings. (*Examination of the Objections made in Great Britain, &c.*, by Dr. Spurzheim. Lond. 1817.) Dr. Spurzheim here says, that Gall and he demonstrated. But he had been engaged by Gall only some months before as his assistant and dissector; and Reil's presents in return were, he confesses, all to Gall. Reil calls them *Gall's* demonstrations, and wonders at such discoveries being made by *one* man. A medal had been already struck to Gall at Berlin (*Bischoff*, p. xvi.); all the attacks for both the Anatomy and Physiology were made upon Gall; and all the accounts of the anatomy and physiology published by his pupils were given as of his discoveries, without the mention of Dr. Spurzheim's name, except once, when he is thus spoken of as Gall's assistant at lecture: — "Gall unfolded the convolutions without any difficulty by means of the fingers of the director Spurzheim." (*Cranologie, ou Découvertes nouvelles du Docteur F. J. Gall, concernant le Cerveau, le Crâne, et les Organes;* ouvrage traduit de l'Allemand. Paris, 1807, p. 32., the original having appeared at Dresden in 1805.) We learn from this, which, curiously enough, is the only notice of Dr. Spurzheim in the early history of Phrenology, how Gall and *he* demonstrated! "While at Vienna, *we* spoke of the great leading points of our anatomical demonstration." "In 1805, at Berlin, *we* repeated our anatomical demonstration." "Outlines of *our* anatomical and physiological propositions were published during that spring by Professor Bischoff." This is the work already quoted. Now, Bischoff speaks of them solely as Gall's, and does not once mention Dr. Spurzheim's name. "At Dresden, M. Bloede published outlines of *our* anatomical and physiological views." I have read Bloede, in the work just referred to, and translated at Paris under the title of *Cranologie,* — a part of which is called *Découvertes Anatomiques du Docteur Gall, d'après l'Exposition du Docteur Bloede,* — and find only Gall mentioned, except in the quotation just made, where he is said to have used the fingers of his managing man Spurzheim to unfold the convolutions. The accuracy of Bloede's work is vouched for on the ground of its being approved of by "the discoverer Gall." (p. xv.) Dr. Spurzheim then goes on to say that Gall and he continued to lecture and demonstrate the brain in Weimar, Jena, Gottingen, Brunswick, Hamburgh, Keil, Copenhagen. Now, he never gave a lecture; and only obeyed Gall's orders mechanically in silence, while Gall was demonstrating. Dr. Spurzheim never then pretended to discoveries; and yet all the great discoveries were already made. Gall assured me that the discoveries, both anatomical and

would weigh several ounces. The ganglions and ganglionic nerves can weigh but little comparatively. Dr. Macartney de-

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physiological, made after he engaged Dr. Spurzheim as his assistant, were merely slight modifications, — *des nuances* were the words he used; and the truth of this is evident to those acquainted with the early literature of the new anatomy and physiology of the brain. Dr. Spurzheim himself affords, in many parts, refutations of his unjust and absurd attempts to arrogate what is not his due. For instance, he says (*Anatomy of the Brain*, p. 148.), "Modern anatomists before Gall and *myself* were divided in opinion on the subject of the decussation." Yet, at p. xi. he says that, having completed his studies in 1804, he was associated with Gall, "and at this period Dr. Gall, in the *Anatomy*, spoke of the *decussation* of the pyramidal bodies; of their passage through the pons Varolii, of eleven layers of *longitudinal* and *transverse fibres* in the pons, &c."!! Yet at p. 5. Dr. Spurzheim says the opinion that the white substance was fibrous is, that "which Dr. Gall and *I* have espoused." An instance of his short-sighted ambition is afforded at p. 95. of his *Anatomy*, where he positively says, "Before Dr. Gall and *I* began our researches, all other anatomists were in the habit of cutting down the brain by slices," &c.; whereas, before Gall ever saw him, Gall had taught his new method to thousands: Gall taught it to him among the rest, and engaged him as his prosector. At p. 178., he says, "Until Dr. Gall and *I* published, it was the custom to take merely mechanical views of these" (the commissures); whereas, in Bloede and Bischoff it appears that Gall taught all the true views of them before he saw Dr. Spurzheim. At p. 110. he says,—"Dr. Gall and *I* claim the merit of having been the first to compare the relations between the development of different cerebral parts and peculiar functions." When every where, even in the first volume of the 4to. work, to which Gall, in the kindness of his heart, affixed Dr. Spurzheim's name with his own, in order, as he often said, to encourage him, and because he thought that Dr. Spurzheim would carry on phrenology after his death as he himself had done, Dr. Spurzheim, like all the world, acknowledges Gall to have been the first discoverer of the functions of different parts of the brain, and of course through observing development. At p. 115. he claims this all for himself! though at p. xvi, of the preface to Gall's 4to. work, with his name added by Gall, this is all given to Gall. "*I* claim the merit of having been the first to maintain that the analogy or differences of cerebral parts in different classes ought to be determined by the combined aid of Anatomy and Physiology!!" Dr. Spurzheim gives another striking refutation of his own assumption. Gall had made and promulgated his discoveries, when Dr. Spurzheim, as he himself admits, *having finished his studies in* 1804, joined Gall. (*Anatomy of the Brain.* London, 1826. p. xi.) Yet, in his eagerness to be equal with Gall, he unluckily writes, in his *Examination, &c.*, "I beg to observe that, in the summer of 1805, *we* demonstrated to Reil the same leading points in the anatomy of the brain which we still maintain!" He whose fingers only were employed on the occasion! he who had joined Gall but a few months from the class room! In truth, the new anatomy of the brain did not consist in this little detail of discovery, or that, but in grand general views of structure; and this

clares he has ascertained the real nervous substance to be so inconsiderable, that he thinks " it is, perhaps, not assuming too much

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was entirely Gall's, and completed before Dr. Spurzheim knew any thing of the matter. Possibly Dr. Spurzheim occasionally made a few little mechanical discoveries, like the person who was Gall's previous dissector, a M. Niklas; of whom Gall says in his preface (4to. vol. i. p. xvi.), " I taught M. Niklas my method of dissecting the brain; and, thanks to his industry and address, he made such progress that he directed my attention to many mechanical points till then unknown." But Dr. Spurzheim, like him, worked under Gall: was ordered to dissect this and that, and to ascertain what was the fact on this point or on that: and the shades of discovery, as Gall terms them, made after he was engaged by Gall, must evidently be ascribed to the working master-mind, and not to the fingers of him who only obeyed, and received his knowledge all but perfect at first, and was *very long* before he could be taught by Gall to dissect a brain decently according to Gall's method. Gall told me that he taught Dr. Fossati in a quarter of the time it cost him to teach Dr. Spurzheim. Because M. Niklas worked and discovered mechanically, Dr. Spurzheim declares (*Notes, &c.*, p. 61.) that the investigations directed by Gall had merely mechanical views, and, referring to the last quotation for his proof, he insinuates that Gall's investigations were too mechanical; whereas, Gall's merit was in rejecting all mechanical views. Dr. Spurzheim's character is put by himself in the strongest light in the *Notes* (p. 60. sq.), by his quoting with triumph a passage from Gall, in which are the words, "beaucoup de personnes manifestent une tendence singulière d'attribuer NOS découvertes à d'autres, par exemple, à Reil; et M. Spurzheim a déjà dans plusieurs endroits revendiqué NOTRE propriété." Now, Dr. Spurzheim knew that Gall used the plural, according to the habit of authors, for the singular: because, immediately before this passage, in the large edition, Gall says, — " *I* have repeated, and ordered to be repeated, hundreds of times, the researches upon the brain. Sometimes *we* thought we had discovered something new; but, by repeating the dissections, *we* have always come back to *our* old ideas. Therefore *I* have no reason to modify what *I* said in the first volume of this work." He then, in both editions, in order, he says, to set those right who ignorantly attribute the discoveries to others, subjoins to this passage the declarations already quoted, of Reil and Loder, respecting *his* anatomical discoveries, which they ascribe to *Gall alone;* and finishes with a summary of all the anatomical and physiological discoveries, speaking of them as *his own* entirely. (Gall, 4to. vol. iv. p. 377. sq.; 8vo. t. vi. p. 490.) In the volume and a half to which Gall affixed Dr. Spurzheim's name with his own, he always wrote in the plural; in the rest, he from the first wrote generally in the singular; and he refers in the singular to what he had said in the first volume in the plural. (See l. c. p. 378. *supra;* and vol. ii. p. 213.) I give another striking instance of Dr. Spurzheim's self-refutation, and the shortsightedness for which he was remarked in Paris when under the influence of his inordinate love of fame. Gall kindly affixed Dr. Spurzheim's name with his own, not only to his great work, but also to the memoir presented to the French Institute. Yet Dr. Spurzheim acknowledges that the Commissioners received the discoveries as Gall's; for, in order to show that Reil must have known the

to suppose that the whole nervous system, if sufficiently expanded, would be found too tender to give any resistance to the touch,

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discoveries before writing, he quotes, in his *Notes* to the *Foreign Quarterly* (p. 59.), the following words, with which they opened their report: — " The anatomical doctrine of *Gall*, through the delivery of lectures by *him* in the chief cities of Europe, and the numerous extracts published by *his* pupils, have become nearly as well known as though they had appeared in an authentic impression." In these *Notes* he says that he settled his anatomical account with Gall in 1820, and that Gall never answered this and other claims. Gall certainly never would have condescended so far. Indeed, Gall was perfectly ignorant of the greater part that Dr. Spurzheim wrote. After reading some of Dr. Spurzheim's first English work, published on his arrival in England, Gall gave the book with disgust, but half cut, to Dr. Fossati, and knew nothing more of Dr. Spurzheim's sayings and writings afterwards than what was pointed out to him; and it was with the greatest difficulty that he could be prevailed upon to take any notice, even for a moment, of what was pointed out to him. My friends Dr. Fossati and Dr. Dancey, who were constantly with Gall, assure me of this, and are astonished at Dr. Spurzheim. Indeed, Gall, in the preface to his third 4to. volume, which contains all the anatomy, had, in 1818, given an answer to all Dr. S.'s anatomical claims. He shews that Dr. S. had no more to do with the volume than to furnish the references. (p. xvii.) At the end of his 8vo. work, Gall also disposes of these claims by summing up the anatomical discoveries as his own. In the American edition of his *Phrenology* (vol. i. p. 12.) Dr. S. grows so ambitious that he no longer shares with Gall, but at once boldly asserts, " all anatomical discoveries made after 1804 are the result of my labours; and in his *Anatomy* (p. xiv.), he madly says, as to Gall's 4to. volume, " My discoveries form its principal object" ! ! !

When Gall was entreated to do himself justice with Dr. Spurzheim, he always mildly answered, that enough had been published of his discoveries before Dr. Spurzheim's time for posterity to see Dr. Spurzheim's folly; and that all the world knew the great quarto work to be his, though he had been silly enough to join Dr. Spurzheim's name with his own. I fear that Dr. Spurzheim relied on Gall's dignified pride for escaping his deserts.

Yet among those who never saw Gall, and who have derived their knowledge second-hand from Dr. Spurzheim's works, and read slightly, or not at all, the works of Gall, and especially those who, in addition to these disadvantages, mixed much with Dr. Spurzheim, his pretensions are allowed. In France he was nothing; his lectures little attended, while Gall's were crowded; and he neglected, while Gall had high practice and the highest consideration. But Gall's works have not been translated, while Dr. Spurzheim published again and again in English, and spent much of his time in Great Britain, and died in America. The result here and in America cannot be better shown than first, in the following ridiculous passage from " an anatomical report on the skull of Dr. Spurzheim, read before the Boston Phrenological Society, by Dr. N. B. Shurtleff, and printed in the *Boston Annals of Phrenology* : — " Having been appointed a com-

too transparent to be seen, and probably would entirely escape the cognizance of all our senses."[u]

The nervous system is invested with peculiar coverings.

"Besides the bony cranium, a threefold covering is afforded to the brain[x], viz. the *dura* and *pia mater*, and, between these two, the *tunica arachnoidea*. These coverings are termed *meninges*.

"The *dura mater*[y]" belongs to the class of fibrous membranes, and "lines the inside of the cranium, like a periosteum, forming various processes. By the falx it divides the hemispheres of the cerebrum and cerebellum[z]; by the tentorium[a] it supports the

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mittee on the skull of our lamented friend Spurzheim, the anatomist, who, by dissecting the brain, first displayed to the eye its fibrous and ganglionary structure, and demonstrated the direction and connection of its filaments," &c.! But the case is much worse, when I mention that this piece of folly and ignorance is published in the last Number of the *Edinburgh Phrenological Journal* (June 1. 1836) without any remark. When I arrive at the subject of Phrenology, I shall resume this task of doing justice to Gall.

[u] l. c. p. 450. sq.

[x] "Eustachius, tab. xvii. xviii.

Haller, *Icones, Anat.*, fasc. vi. tab. i. ii. iii.

Santorini, tab. posth. ii. iii.

F. B. Osiander, in the *Comment. Soc. Reg. Scient. Gotting.*, vol. xvi. p. 105. tab. i. ii.

Detm. W. Soemmerring, *De oculor. sect. horizontali*, tab. i."

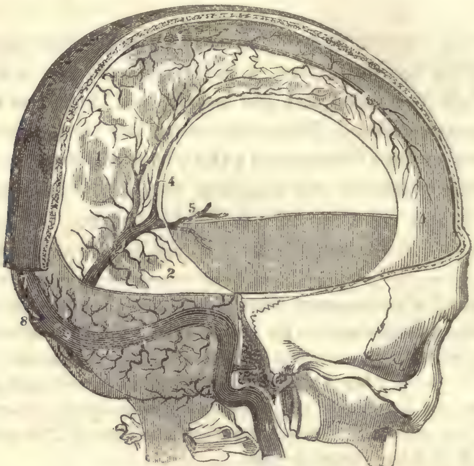
[y] "J. Ladmiral, *Icones duræ matris in concava et convexa superficie visæ.* Amst. 1738. fasc. i. ii. 4to."

[z] Sir Anthony Carlisle, on opening a woman who had died after amputation of a foot, found no falx. The cerebrum was not divided into hemispheres. The edge of the longitudinal sinus was received into a depression, about half an inch deep, that existed along the middle of the superior part of the cerebrum. The head had been unaffected, and the mental faculties perfect, as far as observation was made during the woman's stay in the Westminster Hospital. (*Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge*, vol. i. p. 212. sqq.)

I presented to the London Phrenological Society, the cast of the head of a male idiot, aged eighteen years, that was given me by Dr. Formby, of Liverpool, and is only 16 inches in circumference, and $7\frac{3}{4}$ inches from ear to ear over the vertex. The cerebrum weighed but 1 lb. $7\frac{1}{2}$ oz. The hemispheres were united as far back as the vertex, and no falx existed except for about two inches from the anterior part of the tentorium.

[a] "In the skulls of some genera of mammalia, a remarkable lamina of bone penetrates a duplicature of the tentorium and supports it. Cheselden (*Anat. of the Bones*, c. 8.) supposes this bony tentorium to exist in *feræ* only; but it is found in the equine genus, the cercopithecus paniseus, the delphinus phocæna,

posterior lobes of the cerebrum, and prevents their pressure upon the subjacent cerebellum.



1. Falx. 2. Tentorium. 3, 3. Superior longitudinal sinus. 4. Inferior longitudinal sinus, and, 5. Venæ Galeni; both opening into, 6. The straight sinus. 7. Posterior extremity of the superior longitudinal sinus. 8. A small portion of the left lateral sinus. 9. The confluence of the sinuses, or Torcular Herophili. 10. Right lateral sinus. 11. Internal jugular vein.

" In its various duplicatures it contains and supports the venous sinuses [b]," which receive blood from the veins of the brain, and convey it to the internal jugular vein, " and it prevents their pressure." It is prolonged in a tubular form throughout the canal of the spine, and has openings for the various encephalo-spinal nerves, and is prolonged a very short distance around the greater part.

" Next to the durea mater lies the *arachnoid*, so named from its thinness." It is a serous membrane, " destitute of blood-vessels, and extended, like the dura mater, merely over the substance of

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orycteropus capensis, &c. Its use is uncertain: that which is generally ascribed to it (for instance, by Laur. Nihell, *De Cerebro*. Edin. 1780. p. 4.), — of protecting the cerebellum in those mammalia which leap very swiftly — is improbable, because we find it in the bear and other animals of still slower motion, and not in the ibex which moves with the greatest rapidity."

[b] " Vieussens, *Neurograph. universal.*, tab. xvii. fig. 1.

Duverney, *Œuvres anatom.*, vol. i. tab. iv.

Haller, *Icones Anat.*, fasc. i. tab. vi.

Walter, *De morbis peritonæi et apoplexia*. Berol. 1785. 4to. tab. iii. iv.

Vicq d'Azyr, *Planches Anatomiques*, xxxii. et xxxv."

the brain, without following the course of its furrows and prominences;" but it enters the third ventricle by an oval opening, discovered by Bichat in the base of the telum choridianum, surrounded by the venæ Galeni, and leading from a canal called arachnoidean between the corpora quadrigemina and pineal gland, and it lines the third and afterwards the two lateral and fourth ventricles. It is a close sac, thus affording, as the peritonæum does to the abdominal viscera, a double covering to the whole brain and spinal chord, and to the nerves before their departure through the foramina of the *dura mater*, and lining the four ventricles; insulating the organs on which it lies, and affording them great facility of movement; and liable to all the morbid affections of serous membranes.[c]

Between the pia mater and arachnoid of both the brain and spinal chord, Dr. Magendie says he has discovered the existence during life, of a large quantity of clear and colourless fluid, passing from the surface of one organ to that of the other.[d] Cotugno[e] had long ago asserted its existence in the cranial and spinal cavities, after death, and its free communication, and accurately described its qualities; but, notwithstanding he gave excellent reasons for believing its existence during life, he imagined the space around the spinal chord, observed by him to be larger in the emaciated and old, and the space which in these two descriptions of subjects he found also around the brain, to be filled with an aqueous vapour; he also believed its occasional mixture with the fluid of the ventricles. Many deny at present that more than vapour exists during life and health in any serous membrane. But I certainly saw, as I formerly mentioned, a large quantity of clear fluid pass from the spinal canal the instant that Dr. Magendie opened it, in one of his barbarous experiments, which, I am ashamed to say, I witnessed, and in which he began by coolly cutting out a large round piece from the back of a beautiful little puppy, as he would from an apple dumpling. Dr. Magendie thinks he has proved the communication, not only of the fluids of the spinal with that of the cranial cavity, but also of these with that of the ventricles, by an opening at the point of the calamus scriptorius of the fourth.[f] He conceives it to move from one

[c] Bichat, *Traité des Membranes*.

[d] *Journal de Physiologie*, t. v.

[e] *Dissertatio de Ischiade Nervosa.* Published in Sandefort's *Thesaurus*.

[f] *Journal de Physiologie*, t. vii. p. 21.

part to another, as they are severally compressed by sanguineous turgescence during muscular efforts. He says he never observed the fluid escape at the spot near the venæ Galeni. There is no doubt that he did not, nor by any other: for large serous accumulations often exist in the head, and none in the spine. Most persons have no doubt that the fluid is usually contained, not between the arachnoid and pia mater, but in the serous membrane — the arachnoid. Because, 1st, the true anatomy of the parts shows that the old opinion is wrong,—shows that the arachnoid is a sac like all other serous membranes, and covers the brain and lines the dura mater ; that the ventricles are lined not with pia mater, but with the arachnoid, under which the pia mater exists only as subserous cellular membrane ; and that hydrocephalus is analogous with dropsies of the pericardium, pleura, peritonæum, and tunica vaginalis. 2dly, If the fluid was in the pia mater, it would be under the arachnoid, and the arachnoid, whether of the surface or of the ventricles, would be raised in proportion to its quantity, so that we should find a membrane upon the surface of the fluid both in the interior and exterior of the brain. This is not the case in common; and where it is, as in a case described by Dr. Magendie and one by Dr. W. Heberden, presently to be quoted, the close portion of the arachnoid lies conspicuously upon the fluid.[g] I am therefore satisfied that Dr. Magendie's account is wrong, and that what he calls pia mater in the ventricles is the arachnoid.[h]

Dr. Magendie found the removal of the fluid to occasion immediate dulness and immobility; but says that these disappeared as soon as the fluid was replaced, and that its secretion took place very rapidly. He believes that two ounces may exist in the ventricles without disturbance, but that a larger quantity, whether secreted

[g] I may mention that in a child I saw with hydro-rachitis the aqueous tumour in the loins disappeared, and the head immediately enlarged with hydrocephalus. This looked like any thing but communication.

[h] He appears to me ignorant of the true anatomy of these membranes, and to confound the two, as was the case of old, till the Anatomical Society of Amsterdam confirmed, in 1665, the doubts which were arising on the subject, and Van Horne demonstrated both membranes distinctly to his pupils.

Ackerman contended that fluid always exists in the ventricles, and for the purpose of maintaining a degree of pressure necessary to the functions of the brain ; an increase or diminution of it arresting the cerebral functions. Sir E. Home repeated the same opinions in the *Ph. Trans.* 1814, part ii. See Dr. Spurzheim, *Phrenol.*, Amer. ed. p. 45. sq.

or injected, for example, into the spinal cavity, causes more or less apoplexy and palsy. Much must, however, depend upon the quickness of the accumulation, as the powers of accommodation are very great in living systems, and if the bones expand, very many pints may exist without impediment to the functions of the brain. Dr. W. Heberden knew a man who had been long deaf only, with the exception of vertigo and a temporary attack of confusion, and who suddenly died; when not less than eight ounces of fluid was found in the ventricles, and four on the brain under the arachnoid.[i] Morgagni gives a similar case.[k] Still these might have been instances of rapid effusion.

The blood-vessels of the brain are the two internal carotids and the two vertebrals. They are twice bent at their entrance into the cranium, to lessen the force of the blood; for not only is the organ delicate, but its arteries are thinner and weaker than others of the same size. In some brutes the internal carotid splits, for the same purpose, into a network of vessels, called rete mirabile, which re-unite into a trunk. The veins of the brain pour their blood obliquely into strong, winding sinuses, which transmit it to the internal jugulars (Cut, p. 336.); and the possibility of its reflux into the cerebral veins is thus lessened. The cerebral arteries are said by Béclard to have no third, external coat.

The pulpy substance has an immense number of blood vessels; the fibrous, a smaller number. M. Raspail exhibits one blood-vessel in the membranous investment of the median nerve, and many in the coverings and septa of the ganglion of the sympathetic, but none appeared to enter into the fibres. (Cut 2, p. 326.)

"The membrane, called *pia mater* by the ancients," corresponds with cellular membrane, "closely follows the cortical substance of the brain[l], and possesses innumerable blood-vessels which penetrate into the latter. Hence, if a portion of this membrane is detached, we find the external surface very smooth, while the internal is villous and resembles the roots of moss."[m]. It penetrates into the lateral ventricles at the semicircular fissure which exists on each side between the corpus fimbriatum of the fornix and thalamus opticus; and into the third ventricle, at the central fissure which exists between the posterior extremity of the meso-

[i] *Trans. of the Coll. of Phy.*, vol. v. [k] *Ep. Anat.*, 4. 35.

[l] "Ruysch, *Respons. ad ep. problemat. nonam.* Amst. 1670. tab. x."

[m] "B. S. Albinus, *Annot. Acad.* l. i. tab. ii. fig. 1—5."

lobe and the upper surface of the mesocephalon. These three fissures, united, and establishing a communication between the external and internal parts of the brain, were named the *great cerebral fissure* by Bichat. It runs over the third ventricle, forming with the arachnoid what is called the *velum interpositum* or *telum choridianum;* and the sides of this portion, extended and filled with a plexus of vessels, form with them, in each lateral ventricle, what is called the *plexus choroides*, also, of course, covered by the arachnoid.

The pia mater invests the spinal chord equally with the encephalon, but is there paler and firmer. It also invests all the nerves, and not only their chords and fibres, but their individual fibrils and filaments.

Dr. Macartney finds the pia mater to consist of two portions, one of which is exceedingly subtle and pervades the whole encephalic mass, acting as a framework for the nervous substance. Its delicacy allows the external portion to be readily separated from it on the surface; and it forms, he says, so large a portion of the mass, that the amount of nervous substance, as was remarked above, is very small.[n]

If from deficiency of cranium the brain is seen, it is observed to experience two motions — the one correspondent with the impulse of blood into the arteries, the other correspondent with the distension of the veins by expiration. It slightly pulsates at the stroke of the left ventricle; rising during expiration, and sinking again during inspiration; and it sinks in proportion as inspiration is desisted from the longer.[o]

It is found also in such cases to be more distended during the waking state than during sleep[p]: — a circumstance showing that

[n] *Report of the Third Meeting of the Brit. Scient. Assoc.*, p. 454.

[o] " T. Dan. Schlichting first accurately described this striking phenomenon. *Commerc. litter. Noric.* 1744. p. 409. sq., and more largely, *Mém. présentées à l'Acad. des Sc. de Paris*, t. i. p. 113.

Haller sagaciously discovered the cause of it by numerous dissections of living animals. J. Dit. Walstorf, his pupil, *Experimenta circa motum cerebri, cerebelli*, &c. Gotting. 1753.

Consult also, after F. de la Mure's works, Lorry's dissertations on the same point, *Mém. présentées*, t. iii. p. 277. sq. 344. sq.

Also Portal on a similar motion observable in the spinal chord, *Mém. sur la Nature de plusieurs Maladies*, t. ii. p. 81."

[p] " I once enjoyed an opportunity of very distinctly observing this motion, and making some experiments with respect to it, in a young man eighteen years old.

in active states of the organs they have more blood. Indeed, during strong feelings and intellectual efforts, the brain, in cases of deficiency of bone, has been seen to enlarge, experiencing a turgescence which is common to all organs during their excitement.[q] In emotions, even that of grief, the head not only aches and feels tight, but burns: hard study for many hours has the same effect. The functions of the nervous system, like those of all other organs, require a copious supply of arterial blood; and no solid can perform its living functions but by means of a fluid supplied to it.

Gall considers the pulpy substance of the nervous system as the matrix or producer of the fibrous. It is so copiously supplied with blood vessels, that Ruysch, Schallhamner, Leuwenhoek, Valisneri, Vieussens, Schwendenborg, and almost all the contemporaries of Haller, pronounced it a tissue of fine vessels; and Walter and Ackerman merely a prolongation of finer and finer blood-vessels,— an opinion that Boyer thought probable. Albinus and Sömmerring, however, showed by injection that a soft substance existed as well as the blood vessels.[r] Now, Gall argues, 1. That all parts of living bodies, as is now universally allowed, are gradually and successively developed — that their form and substance, as well as size, totally change from their origin to their perfection — not, as too many had absurdly asserted when he wrote, that all parts pre-existed of inappreciably minute size; and he asks, how the head of the snail reproduced after decapitation, how the transformation of stamina to petals, a work-

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Five years before, he had fallen from an eminence and fractured the frontal bone on the left side of the coronal suture, since which time there had been an immense hiatus, covered by merely a soft cicatrix and the common integuments. The hiatus formed a hollow, very deep during sleep, less so when he was awake; and varying according to the state of respiration, *i. e.* very deep if he retained his breath; much more shallow, and even converted into a swelling, by a long-continued expiration. At the bottom of the hollow, I observed a pulsation synchronous with the pulsation of the arterial system, such as deceived Petrioli, Vandelli, and others, at one time the adversaries of Haller, who all foolishly confounded it with that other remarkable motion which depends upon respiration.— I may add, that this wound on the *left* side of the head had rendered the *right* arm and leg paralytic."

[q] In one such case, during the excitement of one set of organs, the collapse of others was sufficient to produce a depression: and the anger of the person could always be known by merely " the holes which would appear in his head " on the coronal surface, where the bone was defective.— Ed. *Phren. Journal,* Sept. 1835.

[r] Gall, l. c. 4to. vol. i. p. 235.

ing to a queen bee, by modifications of external circumstances, are consistent with the original existence of every part. Thus, as it is clear that one part may produce another which did not exist, that the fibrous portion of the brain may proceed from the pulpy. 2. As all the fibres of nerves are seen to begin in pulpy substance, and, the greater the mass of grey substance, the greater number of fibres are seen to proceed from it; and as, whenever in the brain or spinal chord an enlargement occurs in the fibrous band, there is an accumulation of pulpy matter, that the pulpy appears destined for the production and support of the fibrous[s]; and this not only in regard to nerves, but to the encephalon and spinal chord. For, whenever a portion of the fibrous part of the brain increases, a quantity of pulpy substance is found at the point of increase; just as wherever a branch springs in a tree, its origin is in a mass of soft substance, so that the diameter of all the branches exceeds that of the stem, and they are not divisions of it. Again, before fibres appear at all, the brain and other nervous parts are altogether pulpy and greyish. For, though Dr. Tiedemann asserts that the pulpy substance of the spinal chord is not formed before the fibrous, Gall refutes him in the most masterly manner, showing that he allows the chord to be at first fluid, then " soft, reddish, and sprinkled with numerous small vessels," and that at length, in the course of the first two months, or about the beginning of the fourth month, fibres are seen. These are Tiedemann's own words; and yet he fancies he opposes Gall, who contends for the very same thing, saying, " it is the pulpy, gelatinous, non-fibrous substance sprinkled with innumerable blood-vessels, secreted the first by the pia mater, which engenders, nourishes, and multiplies the nervous fibres." Dr. Tiedemann also objects that, if the swellings or ganglions of the chord were found first to engender the rest, and the nerves corresponding with them, they should be found in the embryo; but that they are not. Certainly this cannot be expected, replies Gall, before the chord becomes consistent, or the period for the production of nerves has arrived; and when the great nerves of the extremities begin to form, and not before, can we expect that the pulpy substance which produces them will be observed.[t] Dr. Tiede-

[s] l. c. 4to. vol. i. p. 44. and p. 242.

[t] See Gall, l. c. 8vo. t. vi. p. 65. sqq. A masterly refutation, but apparently unknown to English anatomists.

Dr. Bellingeri fancies that the pulpy substance is for sensation, the fibrous or motion. I think it is Dr. Foville who fancies that the pulpy is for the pecu-

mann actually says, "Gall is right in asserting that in the adult the parts of the chord most supplied with cortical substance are those where the largest nerves are given off."[u] He allows that nervous fibres go off wherever there are ganglions; that whenever a nerve joins a ganglion, it is reinforced; and that all nerves are accompanied by more or less of this substance, through which they acquire a successive increase, so as to become conical; and that the soft substance is, at the ninth month, more abundant where nerves arise, and still more abundant at the origin of the great nerves of the extremities. Dr. Bellingeri allows the fact of the pulpy far exceeding the fibrous in childhood[x]; and Mr. Mayo allows that the origin of a nerve is always in part from fine grey matter, and that the ascending fibres of the chorda oblongata receive additions from the internal masses of grey matter, "as from new organs."[y]

Old anatomists were perfectly ignorant of the uses of the various parts which they viewed so mechanically, and distinguished by such a collection of strange names. Gall views some of them as organs of increase, others as organs of union, and others as the bands of fibres which execute the nervous functions. What are considered the parts of increase, and what of union, must appear from the descriptions given.

Just as the extreme parts of nerves execute their chief function, as seen in the case of sight, smell, taste, hearing, touch; so, probably, the extreme portions of the fibrous substance of the brain execute its functions. This opinion is rendered the more probable from the pains which I showed nature to have taken to increase the surface of the cerebrum and cerebellum, so that the fibrous substance may ultimately be spread out amidst the pulpy to an immense extent.

The substance of the brain is said to be different from that of all other animal textures. Vauquelin, in 1812, found, in 100 parts,

Water - - -	80·00	Phosphorus - -	1·50
Albumen - -	7·00	Muriate of soda, and phosphate of lime, potass, and magnesia, with sulphur	5·15
White fatty matter -	4·53		
Red ditto - -	0·70		
Osmazome - -	1·12		

liar nervous functions. But Dr. Marshall long ago gave strong reasons for ascribing them to the fibrous. (l. c. p. 239. sqq.)

[u] *Anatomie du Cerveau*, traduit par M. Jourdain, p. 135.

[x] *De Medulla Spinali Nervisque*, S. ii. c. vi.

[y] *Outlines of Physiology*, p. 241. 253. London, ed. 3.

M. Couerbe discovered a large quantity of cholesterine in the brain; and asserts that in the brain of sound persons as much as 2 or $2\frac{1}{2}$ per cent. of phosphorus exists, but about half as much in the brain of idiots, and nearly double in the brain of maniacs! M. John finds firmer albumen and more fat in the fibrous than in the pulpy substance.[z] The oblong and spinal chords, according to Vauquelin, contain more fat, and less albumen, osmazome, and water: the nerves much less fat, much more albumen, and more fat analogous to adipocire. M. Raspail remarks that the investments of the nervous fibrils, chords, and trunks, explain the predominance of albumen. He also reminds us that a nervous dries to a horny substance without putrefying, whereas the brain putrefies in twenty-four hours.

Where *feeling* occurs in matter, mind exists. But the capability of feeling would be useless, were not *volition* united with it. Feeling might exist without will, but could lead to nothing: and means neither of obtaining or protracting pleasant sensations, nor of escaping from painful ones, could be adopted. Volition could not exist without feeling; for we will through motives only. Neither can the existence of feeling be known, but by the certain effects of volition sensible to others. Now feeling may be excited by external things, or by changes within. In the former case, some Scotch metaphysicians term it sensation, and, if an idea of the external thing is also excited, perception: in the latter case, they term it consciousness. When we smell, we have a sensation; when we see an object, we have a perception; when we have a wish, or an idea, or an internal pain, we are conscious. But sensation and consciousness are the same, except as to their immediate causes. Before will is exerted, on the occurrence of feeling, a wish must also be felt — a desire to escape from the feeling, or to increase or prolong it: and, therefore, even in the lowest and most simple cases, a faculty, if so it may be called, probably must be supposed to exist wherever there are feeling and volition.

There are various feelings, and modifications of feelings. The external world produces immediately as many as five kinds

[z] *Journal de Chimie Médicale*, Août, 1835.

in the most complicated beings; so that man is said to have five *external senses* — touch, taste, smell, hearing, and sight. The word touch is used to signify both the power of sensation on the contact of bodies, and also that general feeling which pervades every part, and is able to produce endless varieties of sensations from diversity of causes. If the external world, however, excites merely sensations, the knowledge is very scanty, and the execution of the will and the motives are as limited. But as we ascend in the scale of animals, faculty after faculty is added: so that various properties of the external world are learnt,—form is distinguished, and symmetry, and distance: the relation of colours, sounds, and numbers; and a power is at the same time given for viewing, as a whole, any object which excites these sensations and inner feelings, —so many *internal senses*, as some have named these powers.

As we continue to rise, powers still higher are given;—the power of viewing all things in connection, of comparing, contrasting, inferring: and in some individuals these, to which the term *intellectual powers* is especially given, are of great strength. At the same time, *motives* are given in increased numbers. The lowest animal has little more than a desire for food or life or an agreeable sensation, and an aversion from uneasiness: but to some, a desire of an act for the purpose of continuing the species; to others, a desire to construct a habitation, and in a particular manner; to some, a desire to attack and destroy, &c., is given,—desires few or more and in various proportions. These are all internal feeling, or so much consciousness. Now, any feeling may not only occur, so that sensation, perception, or consciousness are common attributes; but, when a feeling occurs which had occurred before, the circumstance that it is the recurrence of a feeling may be noticed. An odour may be recognised as one smelt before; a desire, a thought, as one experienced before. The philosopher may recognise a great thought as not new to him; and the lowest animal may probably be aware that a savour is the same it experienced once before. This is called *memory*. The impression may return in an obscure manner, without the recurrence of the original cause: so that we feel we had it before, — we remember having witnessed something. Feelings from even external causes may recur without the recurrence of the external cause. The impression is not so lively as when excited originally; if we figure to ourselves a building which we have seen, the feeling, though strong enough for thinking and discoursing

upon, is far short of that experienced with the aid of the external senses. In diseased states of brain, the feeling, however, is as strong as before; as well as where a large portion, but not the whole, of the brain is torpid, or, in other words, a large number of faculties are inactive, and not merely inactive, but roused to full action with difficulty, as in dreaming. The insane and the dreamer, from the powerful action of parts only of the brain, have as strong impressions as though they were employing their external senses.

Any feeling or train of feelings may be thus renewed; a string of words be conceived, though perhaps, at the time, neither heard, spoken, nor written, or even a train of thought. Whether a former impression is directly excited from without, as it was at first, and recognised; or whether feelings of any kind are re-excited from merely internal or indirect external causes of excitement, and recognised; or whether the impression of the former occurrence of any feeling is renewed;—in all these cases of memory, or perhaps more properly, in regard to the two first instances, recognition, the matter is precisely the same.

The mere recurrence of former impressions, without regard to their recognition, is termed *imagination* or *fancy:* and innumerable combinations of past impressions may occur, in such form and order as they did not occur before; and it is to this, strictly, that the term imagination or fancy is generally applied.

Feelings thus re-excited, whether intellectual or moral, do not start up insulated, but draw forth one another in *association*—just as they previously occurred in combination or in succession. An odour will re-excite the idea of the place where such an odour was vividly perceived; and all the circumstances and occurrences of the place will present themselves to the mind in succession or conjunction. It is thus that language spoken and written is an instrument of connection. Any connection between two feelings, of any kind whatever, serves this purpose; and every faculty may be thus excited; and the excitement of the very propensities excites ideas connected with the propensity, and the excitement of any one faculty may excite another.

While any feeling takes the lead, we are said to attend to it. We can for a time keep it steadily vivid. This power is called *attention*. The lowest animal can attend to its sensations, just as the greatest philosopher to his profoundest thoughts. We cannot call up a thought or feeling at pleasure; but, by keeping vividly

before our mind any present feelings connected with it, it sooner or later springs up through association, perhaps very complicated: and in this way, by keeping up impressions connected with certain propensities, we can excite even our propensities. The other mode in which our will operates, is by causing muscular contraction. We can will attention, and will muscular motion.

We are able to compare feelings of all kinds, and to infer one thing from another. This is called *judgment.* The animal, with but two external senses, taste and touch, judges of the quality of what it tastes and touches, — whether the object is like that to which he is accustomed. An animal with sight also judges if the aspect of food or drink is like that to which it is accustomed. With the faculty for the feeling of the relation of tones, it judges of music; with that relating to numbers, it judges of them.

To draw large inferences, see the relation of many feelings, and judge of cause and effect, seems a peculiar faculty; and, like all the rest, may exist in various degrees of force.

All these powers, of course, tend to action; and the various mere propensities are so many tendencies to action. Their impulse is called *instinct*[a]; and their highest tendency to excitement, *passion.* But instinct and passion are common to them all.

These modes or different operations of faculties were considered by old writers, and are still considered by those whose knowledge is but the remains of the ignorance of former days, as fundamental faculties. Every faculty, when it acts, acts in the way of one of them; so that they are nearly common to all our faculties; and, except attention, which is an act of volition, they are all modes only of action. Gall, therefore, instead of dividing them into perception, attention, memory, judgment, &c., as fundamental faculties; and viewing "the Power of Taste, a genius for Poetry, for Painting, for Music, for Mathematics," &c., as "more complicated powers or capacities, which are gradually formed by particular habits of study or of business[b];" regards these last powers as distinct faculties, and perception, attention, memory, judgment, &c., merely as modes or varieties common to the action of each faculty. He contends that, when we see a boy, *brought up exactly like his brothers and sisters,* dis-

[a] Some limit the term instinct to the natural tendency to an act, without any knowledge of its purposes.

[b] Dugald Stewart, *Outlines of Moral Philosophy*, p. 10.

playing fine musical talents or an astonishing power of calculation, *though in all other respects a child,* his pre-eminence cannot be explained by particular habits of study or of business, nor by mere strength of judgment, memory, &c.: — That the boy has a strong perception of melody, a strong memory of tunes, a strong musical imagination, a strong musical judgment, or a strong perception, memory, and judgment, of numbers; but may not be clearer-headed or more attentive on any other point: while men of the strongest sense may have no perception, memory, or judgment, of tunes, or may calculate with extreme difficulty. It is the same with regard to instinct. Writers consider instinct a general faculty, while it is only the inherent disposition to activity possessed by every faculty; and there are, therefore, as many instincts as fundamental faculties. By instinct "the spider spreads a web and ensnares flies: the working bee constructs cells, but does not kill flies to support itself; it takes care of the young, but does not copulate. Many male animals copulate, but take no care of their young: the cuckoo, both male and female, abandons the charge of bringing up its young to other birds, although it is compelled to copulation by a very ardent instinct. The castor builds a hut, but neither sings nor hunts; the dog hunts, but does not build; the butcher-bird sings, builds, and preys; the quail does not mate, but copulates, takes care of its young, and migrates; the partridge mates, copulates, and takes care of its young, but does not migrate; the wolf, fox, roebuck, and rabbit, marry, and take care of their young conjointly with the female: the dog, stag, and hare, copulate with the first female they meet, and never know their offspring. The vigorous wolf, the artful and timid hare, do not burrow like the courageous rabbit and the cunning fox. Rabbits live in republics, and place sentinels, which is done by neither the fox nor the hare. How can these various instincts exist in one species of animals, and not in another? How can they be combined so differently? If instinct were a single and general faculty, every instinct should show itself, not only at once, but also in the same degree; and yet while in the young animal many instincts act with great force, others are still quite inactive: some instincts act at one season, others at another. There is one season for propagation, another for emigration; one season for living solitarily; another for assembling in companies, and for collecting provisions. And how can we explain, on the supposition of a general instinct, why the different instincts do not exist merely separate in dif-

ferent species of animals, but that many of them are even contradictory?" [c]

For my own part, when I reflect upon the *various* talents and dispositions of persons who are all placed in the *same* circumstances, — how unsuccessfully some apply, with the *utmost perseverance*, to a branch of study, in which another, under the *same* instructors, or, perhaps, *scarcely assisted at all*, or even with every *impediment* thrown in his way, reaches excellence with little trouble, and, again, fails in one in which the first is, on the other hand, *successful*,—how early *various* tempers are developed among children of the *same* nursery, — how the best moral education is often thrown away, while in the midst of the worst examples and every incentive to vice a virtuous character is sometimes formed, — how *hereditary* are peculiarities of talent and of character, — how *similar* some persons are to each other in one point of talent and character, and *dissimilar* in another, — how positively *contradictory* many points of the *same* character are found; — how exactly the same is true of all species of brutes[d], and of all individuals among them, as far as their faculties are the same as ours, — each species having its peculiar nature, and each individual its peculiar character: — I confess myself unable to deny that there is one innate faculty for numbers, another for colours, a third for music, &c., &c., with a variety of distinct innate propensities; and that memory, judgment, &c., are but modes of action common to the different faculties.

The faculties of whose existence Gall satisfied himself are: 1. The instinct of generation; 2. The love of offspring; 3. The disposition to friendship; 4. Courage; 5. The instinct to destroy life; 6. Cunning; 7. The sentiment of property; 8. Pride; 9. Vanity; 10. Circumspection; 11. Sense of things, by which we take cognisance of individual objects and occurrences; 12. Sense of locality, or of the relations of space: 13. Sense of persons; 14. Sense of words; 15. Sense of language, or philological talent; 16. Sense of the relations of colours; 17. Sense of the relations of tones; 18. Sense of the relations of numbers; 19. Sense of construction; 20. Comparative sagacity, by which we compare;

[c] Gall, l. c. 4to. vol. iv. p. 332. sqq., 8vo. t. vi p. 352. sqq.

[d] See the poet Cowper's amusing account of the different characters of his three hares. But all persons conversant with horses, dogs, cats, or any other domestic brute, know that every individual among them is proportionally as different in its various abilities and dispositions, from others of its species, as every human being is from other men.

21. Metaphysical sagacity, by which we examine into cause and effect; 22. Wit; 23. Poetic talent; 24. Goodness, and moral sense; 25. Faculty of imitation; disposition to have visions; 26. Religious feeling; 27. Firmness. He had been long inclined to admit also a sense of order and a sense of time, and waited only for proofs of their organs.

Gall gives various other names to each faculty, more anxious to express his view of the nature of each than to quibble for appellations.[e]

For information respecting the precise nature of each faculty, many of which may be ill understood from their designations, I refer to the third and fourth volumes of Gall's work, *Anatomie du Cerveau*, and the third, fourth, and fifth volumes of his *Fonctions du Cerveau* — portions of the work which the most indolent will find entertaining.

That the faculties enumerated are not modifications of each other, or of any other, but distinct and primitive, Gall considers proved by the circumstance of each having one or more of the following conditions.

"An instinct, inclination, sentiment, talent, deserves," says he, "the denomination of fundamental, primitive, radical:

"1. When a quality or faculty (or its organ) is not manifested nor developed, nor diminishes, at the same time with others. Thus the instinct of generation (with its organ) is generally developed and manifested later than other inclinations. Thus, the memory of names usually grows weak sooner than the other faculties.

"When, in the same individual, a quality or faculty is more or less active (and its corresponding cerebral part more or less

[e] Dr. Spurzheim gave to the majority of these faculties new names, which he afterwards changed from time to time, some of which were long and uncouth, and still destitute of the uniformity he aimed at, some new-coined words, and some expressive of a doubtful, if not decidedly erroneous, view of the faculties; and to most of which Gall objected, as I confess I do. Dr. Vimont thus gives his opinion of them: — "Des expressions ridicules. J'ai vu avec plaisir que les medecins les plus distingués en France n'ont jamais pu condescendre à recevoir les mots sécrètivité, marveillosité, &c. — langage prétentieux, de mauvais goût, et qui figurerait à merveille dans la comedie des Précieuses Ridicules, ou des Femmes Savantes." (*Traité de Phrénologie*, 4to. Paris, t. ii. p. 105.) It would have been much better to have followed the example of Gall, and rested contented with a few names for each faculty, so as to show what was meant, and waited till the science is so far advanced that an appropriate name cannot be difficult.

developed) than the others. Thus, the greatest sculptors, painters, designers, have sometimes not the least disposition to music; the greatest poets little talent for mathematics.

"3. When a single quality or faculty is active, whilst the others are paralysed (and only the corresponding organ developed). Thus, persons imbecile in every other respect, are often violently impelled by physical love, or have a great talent for imitation, &c.

"4. When, all the other qualities and faculties being active (and all the other organs sufficiently developed), one single quality or faculty is inactive (and one single organ not developed). Thus, certain individuals cannot comprehend that two and two make four; others detest music, or women.

"5. When, in mental diseases, one quality or faculty only suffers, or one only is entire. Thus, one insane person is mad only in regard to religion, to pride, &c.; another, although mad in every respect, still gives lessons in music with great intelligence.

"6. When the same quality or faculty is quite differently manifested in the two sexes of the same species of animal (and the organ is differently developed in the two). Thus, the love of offspring (with its organ) is more developed in the females of most animals: thus, among singing birds, the male only sings (and has the organ well developed).

"7. Lastly, when the same quality or faculty (and the same organ) always exists in one species and is deficient in another. Thus, many species of birds, the dog, the horse, &c., have no inclination (nor organ) for construction, though this is so strikingly manifested in other kinds of birds, in the squirrel, in the beaver. Thus, certain kinds of animals are predaceous, migrate, sing, take care of their young, while other kinds are frugivorous, lead stationary lives, do not sing, abandon their offspring."[f]

[f] l. c. t. iii. p. 213. sqq. See also 4to. vol. iii. p. 81. These were Gall's own philosophic principles, resulting from a view of his discoveries, and employed by him to test farther discoveries. Yet Dr. Spurzheim details them with no important difference as his own, and says, "I have no hesitation to maintain that, in pointing out the social or fundamental powers of the mind, my proceeding is philosophical, founded on principles, &c.;" whereas "Gall did not determine any of the organs in conformity with these views." (*Phrenolog.*, vol. i. p. 137. American edition.) Gall began, of necessity, empirically; but these were the general principles which he laid down after his discoveries and published in the volumes which bear his name only. "I renounced all reasoning, and gave

Perception, memory, judgment, &c., are modes of action of these distinct faculties. "As often as there exists a fundamental faculty, a particular and determinate intellectual power, there necessarily exists likewise a *perceptive* faculty for objects related to this faculty. As often as this faculty is active upon the objects of its sphere, there is *attention*. As often as the idea or traces which the impressions of objects have left in the brain are renewed, either by the presence or in the absence of these same objects, there is remembrance, reminiscence, *passive memory*. If this same renewal of received impressions takes place by an act of reflection, by a voluntary act of the organs, there is *active memory*. As often as an organ or a fundamental faculty compares and judges the relations of analogous and dissimilar ideas, there is comparison, there is *judgment*. A series of comparisons and judgments constitutes *reasoning*. As often as an organ or a fundamental power creates, by its own inherent energy, without the concurrence of the external world, objects relative to its functions; as often as the organ discovers, by its own activity, the laws of the objects related to it in the external world, there is *imagination*, invention, genius.

"Whether, now, we consider perception, attention, memory, reminiscence, recollection, comparison, judgment, reasoning, imagination, invention, genius, either as gradations of different degrees of the same faculty, or as peculiar modes of being of this faculty, it still remains certain that all the fundamental faculties which have been demonstrated are endowed, or may be endowed, with perception, attention, memory, recollection, judgment, imagination; and that, consequently, it is they which ought to be considered intellectual and fundamental faculties, and that the pretended mental faculties of my predecessors are only common attributes. Here, then, is a perfectly new philosophy of the intellectual faculties, founded upon the details of the natural history of the different modifications of human intellect. The same may be said of the appetitive faculties, or rather qualities."[g]

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myself up entirely to observation. In this way I discovered twenty-seven qualities or faculties essentially distinct, which must all be reduced to fundamental qualities or faculties. It was only after this discovery that I was enabled to point out the characteristic conditions of the fundamental qualities or faculties." (4to. vol. iii. p. 81.) Then follow the seven characteristics.

[g] l. c. 4to. vol. iv. p. 327. sqq., 8vo. t. vi. p. 405. sqq., t. iii. p. 131. sqq.

"When a person has the talent for music, poetry, construction, judging of distance, &c., in only a weak degree, he will not have a very decided inclination for those objects. If, on the other hand, the organs of these fundamental forces are more energetic, the person feels a pleasure in the exercise of their functions; he has an inclination for these objects. When the action of these organs is still more energetic, he feels a want to occupy himself with them. Lastly, when the action of these organs preponderates, the person is impelled towards these objects; he finds his happiness in them, and feels disappointed, unhappy, when he cannot follow his inclination; he has a passion for these objects. Thus it is that certain individuals have a passion for music, poetry, architecture, travelling," &c.[h]

"'You shall not persuade me, however,'" Gall fancies it will be said to him, "'that the faculties acknowledged by philosophers as faculties of the soul, are chimæras. Who will dispute that understanding, will, sensation, attention, comparison, judgment, memory, imagination, desire, liberty, are not real operations of the soul, or, if you please, of the brain?'" "Yes," replies Gall, "without doubt these faculties are real, but they are mere abstractions, generalities, and inapplicable to a minute study of a species, or of individuals. Every man, who is not imbecile, has all these faculties. All men, however, have not the same intellectual or moral character. We must discover faculties, the various distribution of which determines the various species of animals; and the various proportions of which explain the varieties among individuals. All bodies have weight, all have extension, all have impenetrability; but all bodies are not gold or copper, all are not any plant, or any animal. Of what use to the naturalist would be the abstract and general notions of weight, extension, and impenetrability? If we confined ourselves to these abstractions, we should still be in the most profound ignorance of every branch of physics and natural history.

"This is exactly what has happened to philosophers with their generalities. From the most ancient period down to the present day, one has not made a single step farther than another in the precise knowledge of the true nature of man, his inclinations and his talents, or of the source of his motives and determinations. Hence we have as many philosophies as *soi-disant*

[h] l. c. 4to. vol. iv. p. 328. sq., 8vo. t. vi. p. 408.

philosophers: hence the vacillation and uncertainty of our institutions, especially of those which relate to education and criminal legislation."[i]

Gall does not pretend to have discovered the ultimate nature of *all* the fundamental faculties which he has pointed out. The poet's faculty, for example, he regards as distinct and fundamental, because it has the conditions of a fundamental faculty above enumerated; but what are the ordinary functions of that part of the brain, which, when greatly developed, produces the poet, he dares not determine.[k] "I have made it," says he, "an invariable rule to advance nothing which I could not strictly prove, or at least render very probable by very strong arguments: for this reason, in regard to the qualities and faculties, the existence of which I maintain, I have always confined myself to the degree of activity in which I could discover them and observe their manifestation. I know it would have been more philosophical always to refer to their fundamental forces the qualities or faculties which I could detect in only their highest action: but I preferred leaving something for those who came after me to do, rather than give them an opportunity to disprove what I had prematurely advanced."[l]

[i] l. c. 8vo. t. i. p. 49. sq. See also 4to. vol. iv. p. 318. sqq., and 8vo. t. vi. p. 392. sqq.

[k] l. c. 4to. vol. iv. p. 181., 8vo. t. v. p. 243.

[l] l. c. 4to. vol. iv. p. 275. sq., 8vo. t. v. p. 407. Gall was of opinion that there is a faculty for judging of time, and another of order. (l. c. 4to. vol. iv. p. 61. sq., 138. sq., 8vo. t. iv. p. 466. sq., t. v. p. 153. sqq.) He held, that there must be a faculty which determines the desire of a particular habitation (l. c. 4to. vol. iii. p. 314. 8vo. t. iv. p. 280.), and might be one which gives pleasure in wonders; but, like the faculties of time and order, he "was always of opinion that they should not be received into the list till the situation of their organs was proved by a sufficiently large number of exact observations." (l. c. 4to. vol. iii. p. xxiv. sq.) Dr. Spurzheim and phrenologists in general admit all four. Dr. Spurzheim splits Gall's sense of Things into two: one for objects, and one for occurrences. Gall conceives there is a cerebral organ for the desire of taking food (l. c. 8vo. t. iv. p. 63.); and Dr. Hoppe of Copenhagen is generally thought to have established it. (*Phrenolog. Journ.* Edin. Nos. 5. and 7.) Dr. S. assigns its establishment to a person who never uttered a word to us upon the subject till, many months after Dr. Hoppe's first paper was published and six weeks after the second paper had been read in the Edinburgh Society, he surprised us all in the London Phrenological Society by reading a paper upon the point. Gall originally fancied that there was a faculty of the love of life, and that he had discovered its organ; but he afterwards thought he had been mistaken. *Cranologie,*

Neither does Gall pretend to have enumerated all the fundamental faculties of the mind. "Probably," says he, "those who

ou Découvertes nouvelles du Docteur Gall, traduit de l'Allemand. Paris, 1807, p.72. Gall, 8vo. t.iv. p. 63. sq.) Dr. A. Combe, however, in the *Ed. Phr. Journ.*, 1826, contended that the love of life was a distinct faculty, and mentioned the case of an old lady who had long been remarkable for her love of life, and in whose brain the only thing peculiar was an enormous convolution at the base of the middle lobe. Dr. Spurzheim, without referring to Dr. A. Combe or any one else, coolly says *he thinks* "it is highly probable that there is a peculiar instinct to feel a love of life; and I look for its organ at the base of the brain, between the posterior and middle lobes, inwardly of combativeness." (*Phrenology*, ed. 1832, vol. i. p. 142.) Dr. Vimont says (*Traité de Phrénologie*, 1835, vol. ii. p. 165.), that persons assured him that Dr. S., in his lectures at Paris, in 1830, arrogated to himself the discovery of the organ. Dr. Vimont, however, is equally culpable with Dr. S.; for he not only says that Dr. S. made no such discovery, but that neither Gall nor Dr. S. speaks of the faculty; and Mr. G. Combe only in the third edition of his *System of Phrenology*, in 1830. Now, 1. Dr. Spurzheim did mention it in his edition of 1832, under the beautiful name *vitativeness*; and Gall long before, though to disprove it. 2. In the passage which Dr. Vimont refers to, in Mr. G. Combe's work, the case seen by Dr. A. Combe is fully detailed from the *Ed. Phr. Journ.*, vol. iii. p. 467. sqq., published in 1826. But, Dr. Vimont's mention of it is in his second volume, published 1835, p. 105. and 160. sqq.; and he there says that he mentioned it in a memoir presented to the French Institute only in 1827.

Gall, in treating of attachment, gave strong reasons, in opposition to Dr. Spurzheim, for believing that there is a faculty for marriage. Dr. Vimont fancies that he himself has established this; as well as, in certain brutes, a faculty which he calls *sens géométrique*, inclining them, when moving in numbers, to arrange themselves in a certain figure; and one in men, which he terms *sens du beau dans les arts*. Dr. Spurzheim conceived that there is a distinct faculty for judging of weight or resistance, one for judging of size, as well as one of hope.* Gall was opposed to all three. In Edinburgh they fancy there is a faculty for keeping other faculties in simultaneous action towards one object, and they call it concentrativeness. Dr. Spurzheim argues against it through no fewer than eleven pages; and Gall considered it unfounded. Dr. Spurzheim says that a friend of his, a M. De Tremmon of Paris, suggested the idea of an organ of which agriculture is the result. (*Phr.*, Am. ed. vol. i. p. 168.) An Irish gentleman, who had just commenced the study of phrenology, announced the discovery of seventy-four new faculties one night to the Phrenological Society of London. It appears to me, however, that there must be a faculty which makes us wish to communicate our ideas to others, and another which makes us love society. Some persons can keep nothing for an instant. Now no want of secretiveness (if there is such a faculty, though Gall more properly, as I imagine, con-

* *Phrenology, or the Doctrine of the Mental Phenomena.* By G. Spurzheim, M.D. 2 vols. Boston, 1832. Editions of some of his works, with his latest corrections, were printed there by Marsh, Capen, and Lyon, 1832–3.

follow me in the career which I have opened, will discover some fundamental forces and some organs which have escaped my researches."

He doubts, however, whether so many will be discovered as some apprehend. A modification of a faculty must not be mistaken for a faculty, nor the result of the combined action of several faculties for a particular faculty. "If," he says, "we reflect on the number of possible combinations which may result from the twenty-seven or thirty fundamental faculties or qualities, from the reciprocal action of as many organs, we shall not be surprised at the infinite number of shades of character among mankind. How many different combinations result from the ten ciphers, from the twenty-four letters. How many different countenances result from the different combination of the small number of parts which compose the human face: how many shades of colours and tones result from the small number of primitive colours and fundamental tones." [m] They, moreover, may be variously modified in different animals.

This view of the mental faculties may be considered quite independently of the peculiar doctrines of Gall respecting the cerebral organs of each faculty, and even quite independently of the fact of the brain being the organ of the mind. It may be examined precisely like the metaphysics of Locke, Reid, Stewart, Brown, &c. [n]

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siders that what Dr. S. names secretiveness is a disposition to artfulness and stratagem) can explain it. There must be a positive propensity. The disciples of Dr. S. must allow that the want of a disposition to conceal would not impel a person to communicate; as they maintain, in opposition to Gall, that the deficiency of combativeness will not give fear, nor of any feeling its opposite. Again, some persons, not at all remarkable for attachment, cannot bear to be alone; they have a propensity to society too strong to allow them to be alone a moment, though they have no regard for the person whose presence may suffice them. Gall is decidedly of this opinion (l. c. 4to. vol. iii. p. 175. sq., 8vo. t. iii. p. 492. sq.); and, having been unable to localise the tendency, is inclined to regard it as a modification of attachment. Solitariness and silence are dreadful punishments.

[m] l. c. 4to. vol. iv. p. 275., 8vo. t. v. p. 406. sq. Bacon, *De Dignit. et Aug. Sc.* l. vii. cap. ii. is striking on this point.

[n] It is remarkable that nearly every one of these faculties has been admitted by one metaphysician or another. See Mr. G. Combe's Letter in reply to Mr. Jeffrey, the editor of the *Edin. Review,* reprinted in the *Edin. Phrenol. Journal,* 1827.

Notwithstanding, too, that memory, like judgment, attention, &c., was con-

It, however, derives its great proofs from the fact of the individual faculties being, cæteris paribus, strong in proportion to the development of particular parts of the brain, as we shall presently see.

Every faculty was given us for a good purpose, and it is only when one or more are excessive, or defective, or too much or too little excited by external circumstances, or by disease, that error occurs. The lower faculties given to brutes as well as to ourselves are evidently to yield to those which are of a superior nature and peculiar, or given in a higher degree and with peculiar modifications, to man. Happiness is "our being's end and aim." Not individual, partial, temporary happiness, however intense; but the greatest and longest happiness of the greatest number. Sound morality in individuals and nations,—and in what, through elective representation should be, at least virtually, identical with a nation,—government, tends to this. No act is virtuous that does not lead to the greatest happiness of the individual and of the greatest number of individuals: nor does any act lead to the greatest happiness of the individual and of the greatest number, that is not virtuous. The whole set of faculties, each allowed to act, but the inferior in subordination to the superior, lead to virtue; and this to happiness. "All the faculties," says Gall, "are good, and necessary to human nature such as it should be according to the laws of the Creator. But I am convinced that too energetic an activity of certain faculties produces vicious inclinations — causes the primitive destination of propagation to degenerate into libertinism, the sentiment of property into an inclination for theft, circumspection into irresolution and a tendency to suicide, self-love into insolence, disobedience, &c." [o] To employ all our faculties so as to produce the largest amount of individual and general happiness, therefore, is the law of our nature; and, like all the laws of nature, is intended to be obeyed. When we attempt to act contrarily to any law of nature, evil arises either to ourselves immediately or ultimately, to others

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sidered a distinct and fundamental faculty, some writers taught that there were three sorts of memory; one for facts (*memoria realis*), one for words (*memoria verbalis*), and one for places (*memoria localis*). See Gall, l. c. 4to. vol. iv. p. 14. sq., 8vo. t. iv. p. 380. Some, that there are four; a memory for words, another for places, a third for time, and another for cause and effect, or causality. See Gall, l. c. 4to. vol. ii. p. 357. sq., 8vo. t. ii. p. 353.

[o] l. c. 4to. vol. iii. p. xxxi.

contemporaneous with us, or to our successors, be they our progeny or not. To obey them is, therefore, our solemn duty. Christianity teaches the very precepts which lead to the greatest happiness: and, if any one disregard the authority of them as taught by Christ, because he sees no proofs of Christ's superhuman authority, he must remember that they are already established in nature; and that Bishop Butler himself, in his *Analogy*, declares that man, "from his make, constitution, or nature, is, in the strictest and most proper sense, a law to himself, — he hath the rule of right within,"[p] and that Christianity, as regards its moral precepts, is a republication "of natural religion in its genuine simplicity," and that "moral precepts are precepts the reason of which we see," and "arise out of the nature of the case itself, prior to external command."[q]

So imperative are the natural moral laws, that a man is equally bound to obey them and be virtuous, though he disbelieves not only the divine authority of Scripture, but a future state. Indeed, in proportion to the necessity of being influenced in our conduct by the hope of future reward or the fear of future punishment must be the deficiency of real virtue. Nay, a man would be equally bound to obey the moral laws, though, notwithstanding the evidence of universal design, he should, from the difficulties of the subject, reason himself into a doubt of the personality of

[p] *Sermon* iii.

[q] *Analogy*, P. ii. c. i. Melancthon says, "Wherefore our decision is this, that those precepts which learned men have committed to writing, translating them from the common sense and common feeling of human nature, are to be accounted as not less divine than those contained in the tables given to Moses; and that it could not be the intention of our Maker to supersede by a law given on a stone, that which is graven with his own finger on the table of the heart."

Volney's *Loi Naturelle* deserves reading; and that part of Dr. Spurzheim's *Phrenology* which relates to the moral constitution of man. Mr. Combe's work on the *Constitution of Man* is plain and forcible, and should be in every body's hands, as a guide to happiness and a protection from absurd and superstitious notions. Through a phrenological benefaction, its price is very low.

Upon the subject of metaphysics, or the science of mind, all our knowledge, I think, may be found in Gall's works, — *Sur l' Anatomie et Physiologie du Système Nerveux*, and his *Fonctions du Cerveau*; in Dr. Spurzheim's *Phrenology*, in 2 vols; and in the admirable *Lectures on the Philosophy of the Human Mind*, by Thomas Brown, M.D. Edinb. 1826, 1 vol. 8vo.

Dr. Thomas Brown is not only among the ablest metaphysical writers, but is the latest, and his work approaches as near to phrenology as was possible without the aid of Gall's method of investigation.

the great cause of creation. The wicked man who holds any of these opinions, in the idea of being loosened from the bonds of virtue, is as ignorant as he is wicked.

Bishop Butler, in his profound metaphysical sermons, preached at the Roll's Chapel, and which all should study, proves that the natural tendency of all our united faculties and feelings is to virtue and the greatest happiness.[r]

[r] *Serm.* i. Upon the social nature of Man. *Serm.* ii iii. Upon the natural supremacy of conscience.

Some have, in the most bigoted manner, denied that there is any foundation for virtue, but in revelation. " I never took any pleasure in *moral ethics*," says Mr. Gilbert Wakefield (*Memoirs of his own Life*, vol. i. p. 512.), " and would not give one penny for all the morality in the world." Yet, as the present Dean of Peterborough, Dr. Turton remarks (p. 222.), " this gentleman wrote a book of about 230 pages in defence of Christianity ; and the volume is almost entirely confined to the internal evidences and moral excellence of the system. It is not unpleasant to observe the natural feelings of people thus completely overthrowing their theoretical positions. ' Natural religion,' Dr. Hey observes ' is pre-supposed in revealed.' " Socinus even declared (Toulmin's *Memoirs of Faustus Socinus*, p. 216.) that no man could discover the truths of natural religion, not even the being of God, by the light of nature ; " and that the first notices of a Divine Being were derived from Revelation or immediate communications from God." Archbishop Magee held the same doctrine ; and Bishop Horne and the greater defender of the Trinity, Mr. Jones, went further, by believing the Bible to contain a system of natural philosophy (" as certain critics," equally absurd in regard to another book, " are used to say, hyperbolically," that if all sciences were lost, they might be found in Virgil, (Lord Bacon, *Advancement of Learning*), and, by becoming disciples of a person named Hutchinson, who thought that, by the " light which revelation afforded him, compared with his own observations, he saw farther into the constitution of the universe, and the operations carried on in it, than Sir Isaac Newton had done." (Bishop Horne's *Works*, vol. i. p. 445.) " Mr. Hutchinson looked upon natural religion as an engine of the devil, in these latter days, for the overthrow of the Gospel ; and therefore boldly called it the religion of Satan or Antichrist." The fancy was, however, old. " Paracelsus and some others," says Lord Bacon (l. c.) have pretended to find the truths of all natural philosophy in the Scriptures, scandalising and traducing all other philosophy as heathenish and profane." " But neither do they give honour to the Scriptures, as they suppose, but much embase them." " The scope or purpose of the spirit of God is not to express matters of nature in the Scriptures otherwise than in passage, and for application to man's capacity and to matters moral and divine ; and it is a true rule *auctoris aliud agentis parva auctoritas ;* for it were a strange conclusion, if a man should use a similitude for ornament or illustration sake, borrowed from nature or history, according to vulgar conceit, as of a basilisk, an unicorn, a centaur, Briareus, an Hydra, or the like ; and that therefore he must needs be thought to affirm the matter thereof positively to be true." — The mind is a subject of natural

We will now consider the special functions of the different parts of the nervous system.

The mind is evidently the property of the brain; and the operations of the mind, whether relating to sensation, will, intellect, or affections, are evidently the operations of the brain. In the division of this work devoted to general physiology, I proved the brain to be the organ of the mind, as much as the liver is the organ of the secretion of bile; that what holds good of the function of every other part, holds good of the function of the brain; and that to ascribe the power of the brain to an immaterial imaginary something called a soul, is a mere hypothesis, the remains of unenlightened times, and not only unnecessary to the belief of a future state through a divine revelation, but calculated to throw discredit on such revelation, by making its annunciation of a future state appear superfluous.[s]

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science, and Lord Bacon's remarks apply to it equally as to astronomical and geological matters; and I consider that a soul stands upon the same foundation as a centaur or a Briareus.

[s] An old argument, which I thought too puerile to notice, and which was disposed of by Gall (l. c. 8vo. t. iii. p. 119. sq.), has just been revived by Lord Brougham to uphold the existence of something called soul distinct from matter. (Paley's *Natural Theology, illustrated* by Henry Lord Brougham. London, 1835. The body is said to be incessantly changing its constituent particles, so that no part of it is the same after a certain lapse of time; and yet we feel ourselves to be mentally the same. Now, the change of the particles of the body may be granted. But what then? Do not all the properties of all parts of the body remain the same, as much as its mental character? are not the fresh particles so assimilated to each part, that all we can see or feel of our bodies, and the qualities of every part, remain the same, as much as all we observe of the mind, throughout all the changes of particles? Is not a man held to be the same bodily as well as mentally all the days of his life? If the face is marked with the small-pox, do not the pits remain throughout life, though the particles may have all changed ten times? If a nervous or dyspeptic affection exists hereditarily, does not the morbid functional peculiarity continue through all the repeated changes of the particles? If a person acquires immunity from small-pox by vaccination, or by having once passed through the disease, is he not in nearly all instances safe against it, though he live long enough to change all his particles again, and again, and again. What is true of all other organs and parts is true, to just the same extent, of the brain, in regard to its substance and its qualities.

An assertion of Lord Brougham's, that the mind does not decay with the body, but acquires vigour while the body declines, is incorrect. "It is equally certain," says he, "that while the body is rapidly decaying, between 60 or 63 and 70, the mind suffers hardly any loss of strength in the generality of men: that men continue to 75 or 76 in the possession of all their mental powers, while few

If it is clear that the brain is the organ of mind, it is extremely probable that particular portions of it have different offices.

can boast of even their physical strength; and instances are not wanting of persons, who, between 80 and 90, and even older, when the body can hardly be said to live, possess every faculty of the mind unimpaired." (p. 120.) This statement is perfectly opposite to sound observation. Gall published when between 60 and 70, and in conversation appeared in full possession of his intellect; nay, as to cerebellum and body at large, he declared that he never omitted matrimonial duties for 24 hours. Madame Gall assured me, in regard to the whole man, "que le docteur n'étoit pas épuisé; que ses forces n'étoient pas diminuées!" But what he wrote did not contain a single discovery or new view, and was merely the offspring of his former labours and mental powers. He told me his mind's vigour was impaired, and his head somewhat diminished. A man's judgment may become greater near 60; not from greater strength, but from enlarged experience and longer habit. But let him attempt what is not habitual with him, or let him attempt originality, and, though he may not discover his decline, the rest of the world will. The Archbishop begged to be informed when his sermons showed his mind to be falling off; but was offended beyond forgiveness when Gil Blas told him that his last homily "ne paroît pas tout-à-fait de la force des précédents." "Mon esprit, grace au Ciel," replied the indignant old man, "n'a rien encore perdu de sa vigeur." When old men work at something original, or pursue a course of public intellectual effort, their falling off is manifest, and we discover that the phrase 'retained their faculties to the last,' is vague and incorrect, just as I formerly remarked it to be when applied to persons near dissolution. I am not aware of any great discoveries or original productions by men who had attained the age of 60; but, should any instances of full mental vigour in old men be adduced, they would only be exceptions, just like octogenarian fathers, or persons who we see continually in the papers lived to 90 or 100, and walked so many miles daily to within a week of their death for I know not how many years. An eminent agriculturist has been begetting a family at past 70.* Yet who would fix upon a man of 70 as a postman, or to ensure an heir? Are not elderly men found to fall off from their full and palmy condition of mind, till they all acquire the title of old women? There may be varieties in the period of general decline, as there are of full development; and there may be varieties in the decline of different organs in the same system. Will not the stomachs of some old men receive and digest food as well as those of young ones? But decline arrives; and those who use such arguments should show that the

* Every Sunday newspaper records the death of some wonderful old poor person, and I take this by chance from the *Morning Chronicle* of the 30th of last November. "The veteran Lord Lynedoch has been visiting at Holkham; and we are happy to understand that, notwithstanding his advanced age (we believe the venerable General to be in his ninety-second or ninety-third year), he enjoys the diversion of shooting, and sees well enough to kill a hare. Mr. Coke (the agriculturist I alluded to) enjoys and directs the battues with the same health and energy he has done for many years."

Numerous old writers had assigned situations for the faculties, but in the most fanciful manner; and, from regarding as distinct

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mind does not require sleep, is not weakened by over-exertion of the brain or any other part, by want of food, by cold, &c., and is not affected by narcotics and stimulants. Those who wish to show the mind independent of the brain in one point, must show it in all.

In reply to the argument for an immaterial something from the consciousness of personality, I reminded my readers formerly that the fly must be as conscious of its individual being — its personality — as the philosopher about whose head it buzzes. If he must be believed to have an immaterial and immortal soul on this account, so must the fly, and so must the smallest microscopic creature. Nay, if an animal is of such a nature that it will re-acquire bodily perfection, or can live when divided into two or more, its mind can do the same: so that a *planaria's* consciousness may be made into two or ten if we please (see suprà, p. 254.) — each new animal made from sections having its sense of personality, and therefore its pretension to an immaterial principle, as much as the original and as much as a philosopher; and simply because its sensorial nervous system, though divided, fully thrives. Our own minds, and those of all other animals, are known to us only as powers generated merely by matter, through being of a certain composition and placed under certain circumstances, possessing or acquiring the property of changing and developing, till at length brain results, with its mental properties; and, as the respective parts of this brain are farther improved in texture and developed, so increased and fresh faculties appear. The properties of every other organ come in the same way.

Lord Brougham (p. 102. sqq.) censures former writers for not using an argument which, unfortunately for their characters as observers of nature, was used by Drs. Barrow (7th *Sermon on the Creed*), Bentley (*Sermon* ii.) Clarke (*On the Being and Attributes of God*, Prop. viii.), Reid (*Essays on the Powers of the Human Mind*, vol. i. p. 97.), Beattie (*Dissertations*, chap. i. sect. i.). A particular combination of matter, he asserts, cannot give birth to what we call mind, because this would be "an assertion altogether peculiar and unexampled," of which "we have no other instance;" because "we know of no case in which the combination of certain elements produces something quite different, not only from each of the simple ingredients, but also different from the whole compound," — "both the organised body and something different from it and not having one of its properties — neither dimensions, nor weight, nor colour, nor form." (p. 102. sqq.) — "To think," says Dr. Barrow, in anguish, "a gross body may be ground and pounded into rationality, a slow body may be thumped and driven into passion, a rough body may be filed and polished into a faculty of discovering and resenting things; that a cluster of pretty thin round atoms (as Democritus, forsooth, conceited), that a well-mixed combination of elements (as Empedocles fancied), that a harmonious contemperation (or crasis) of humours (as Galen, dreaming, it seems, upon his drugs and his potions, would persuade us); that an implement made up of I know not what fine springs, and wheels, and such mechanic knacks (as some of our modern wizards have been busy in devising), should, without more to do, become the subject of

faculties what are merely modes of action of faculties to which they were altogether strangers, their assertions on the subject were

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so rare capacities and endowments, the author of actions so worthy and works so wonderful, &c. &c. — how senseless and absurd conceits are these! How can we, without great indignation and regret, entertain such suppositions?" As a son of Galen, I would reply to Barrow ("dreaming, it seems, upon his" dusty folios of divinity in his study, instead of looking abroad through nature) and to Lord Brougham, — 1. That the brain, matter though it be, is seen, in positive fact, to have these capacities and endowments — that it has them in proportion as it is better organised and has a greater bulk of its respective portions — that the mental phenomena are disturbed by all the means, applied to the brain, that disturb the functions of other organs when applied to them: 2. That there is an insensible transition of mental qualities from the lowest brutes through the cleverest, and through human beings of the dullest apprehension and feelings (many of whom are far below most brutes) to the highest among us; and that the mental properties of the lowest are neither "dimensions, nor weight, nor colour, nor form," any more than the mental properties of ourselves, and must therefore arise from something more than matter, or our high capacities may be merely properties of matter. What faculty or degree of faculty that appears in the scale of animals is the first sign of soul? Nay, the properties of simple life, such as vegetables have in common with us, are neither "dimensions, nor weight, nor colour, nor form,"— they cannot be produced by "grinding, pounding, thumping, driving, filing, polishing, by springs, wheels, and such mechanic knacks." They, I suppose, are not now ascribed to a soul, though they once were, and ought to be still by such believers in souls.

The vital properties of a cabbage, I presume, are allowed to result from a well-mixed combination of elements; and if such a combination produces such a result, other combinations may and do produce results still higher. What in common with extension, impenetrability, and inertness, have heat, electricity, magnetism? yet matter placed under certain circumstances displays these properties; and a change of circumstances changes them. Biniodide of mercury is yellow; but reduce its temperature to a certain point, nay, only touch it, and instantly it becomes red. Soft iron and nickel have magnetic properties at a certain temperature, but suddenly lose them at a higher, and nickel at a less elevation than iron. Soft iron connected with a magnet, or encircled by a coil of copper wire and connected with a galvanic battery, becomes magnetic, but no longer than the connection lasts.

What property of dimension, weight, &c., is that possessed by mercury, iron, and so many other elements, of variously affecting living natures, both corporeally and mentally? A few elements combined in various proportions acquire various such properties, and, in some, properties of the most deadly kind. Prussic acid is only certain proportions of carbon, nitrogen, and hydrogen — all which, in other proportions and combinations, are essential elements of our bodies. The living matter of vegetables and animals is common matter arranged and compounded as in no other instances, and which, properly circumstanced as to temperature, &c.

necessarily groundless and ridiculous. Burton, for example, in his compilation, says, "*Inner senses* are three in number, so called

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gives rise to the phenomenon of life. When living matter arranges itself, according to its properties, into that peculiar combination which we call nervous, other peculiar phenomena appear; and if its vital powers arrange it into that composition and organ called brain, and this is properly circumstanced, mind appears. In truth, no combination of elements and arrangement of matter thus combined occurs in inanimate substances as we find in vegetables; no such combination of elements and such organisation in vegetables as we find in brutes; and no such combination and organisation in the other organs of brutes as we find in the brain, and the brain of no brute is equal to the development of its various parts to the human brain. The vital and mental phenomena are unexampled in the inanimate world — result from no combination or organisation there, simply because no such combination and organisation occur in the inanimate world. Combine and organise inanimate matter by supplying seeds and young plants with proper inanimate matter, and every vegetable may be generated from one or two, in indefinite abundance, as long as matter is supplied and necessary circumstances attainable; and you give living properties to matter previously inanimate. You may do this equally with animals, and thus multiply minds; you may do it equally with human animals, and thus multiply human minds indefinitely — generate souls! Nay, you may generate what quality of mind you please, just as you may generate the properties of a rose, or of a lily if you prefer them, by propagating from a rose or lily, thus converting inanimate matter into roses or lilies; and just as you can propagate the intellectual and moral qualities of the intelligent and affectionate dog, or the musical qualities of the bulfinch, if you prefer them, by propagating dogs or bulfinches, thus converting inanimate matter into dogs and bulfinches. You may generate not only human faculties, but any variety of them you please, as much as you can varieties of body, by propagating and feeding different varieties of human beings, — by converting common matter into human beings, and human beings of whatever sort is preferred. Propagate from cretins in Switzerland, and you have idiotism; from sagacious parents, and you have intelligence; from parents endowed with a specific talent, you produce this talent, be it musical or any other; from violent, vicious, half mad parents, and you beget a curse to mankind, in ferocity, depravity, or eccentricity; from mad parents, you produce madness; from the gentle, and benevolent, and affectionate, you generate gentleness and love. With but one parent so marked, you may often succeed in generating his or her qualities; and when, with two alike, you fail, the failures are not more frequent, nor caused by other circumstances, than failures of transmission of corporeal resemblances, or of the transmission of the mental qualities of brutes or of the properties of vegetables. Strange souls, to be thus under our command as to numbers and qualities! So far from there being, as Lord Brougham says, no case in which the combination of certain elements produces something quite different, the world is incessantly filled with such cases; all the vegetable and animal creation are examples of inanimate matter incessantly combined into the production of new qualities totally different from those previously possessed.

because they be within the brain-pan, as *common sense*, *phantasie*, and memory." Of "common sense," "the forepart of the brain is

It is asserted by Lord Brougham, who positively says that we have a "perpetual sense that we are thinking," "quite independent of all material objects," (p. 56.) that the circumstance of the existence of matter is only an hypothesis, and that materialists grossly and dogmatically assume that matter exists. Now, we do not assume — we know, that matter exists. From certain sensations, we believe inevitably, intuitively, by the laws of God, that what we term matter exists. He allows, indeed, "that we believe in the existence of matter, because we cannot help it." (p. 241.) This is enough. As to our minds, we observe that no mind exists in nature but as a property or power of matter. We never see mind. We certainly learn the existence of matter by the property of our brain called mind : but that is no reason for saying that the power called mind exists alone. If it were felt by ourselves to exist, though we had no knowledge of matter around us, it would only show that we felt personality without knowing the cause of it, — without knowing that we had brains. It would show our ignorance only. The elephant, and whale, and the smallest insect, with their sense of personality as real as ours, know nothing of their brains ; yet *we* know that their mind belongs to a brain. If even we were ignorant of the external world, we should know there is something more than an immaterial soul without dimensions. For, though we could live for a time without our external senses, we could not live a few minutes without breathing. We should, as usual, internally feel our personality in that part of space where our head is. We should also internally feel the uneasiness arising from want of breath at a distance from this—in the part of space where our lungs are. We should be compelled to will a motion to remove this uneasy sensation. All this must inform us of matter. Nay, could we live without breath,—mere heads, since the head might ache in different parts, we should have internal evidence of extension. When Lord Brougham reminds us that we learn the existence of matter only by our minds, he should remember that we are not conscious of our existence till matter makes an impression upon us. The existence of mind as a property of peculiarly arranged and circumstanced matter was fully proved before, and therefore these considerations, like every other fact, harmonise with the account; and the doctrine of the existence of mind, independently of matter, indicates a want of modern knowledge and involves us in endless absurdity. Its studied display usually proceeds in our profession from rank hypocrisy and malice, as though a materialist may not be a devout Christian, and these pharisees say aloud, "I thank thee, Lord, that I am not as other men are — even as this materialist." I agree with the early Christians and Mr. Carmichael (*An Essay on such Physical Considerations as are connected with Man's ultimate Destination, &c.*, by Andrew Carmichael, M.R.I.A. Dublin, 1830.), that, as all nature is one whole, all other created beings are also organised. They and we are in but one spot at a time, and can move from one spot to another : what does so, cannot be else than matter and a property of matter. I consider this alone a proof that we possess no such imaginary thing as an immaterial soul. A masterly exposure of Lord Brougham's strange misstatements and sophisms on the subject of materialism will be found in *Observations on the Discourse of Natural Theology by Henry Lord Brougham*; by Thomas Wallace, Esq. LL.D.

his organ or seat;" of "phantasie or imagination, which some call *estimative* or *cogitative*," "his *organ* is the middle cell of the

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one of his Majesty's Councillors in Ireland. London, 1835. An equally able and very learned exposure of the innumerable literary errors of this unfortunate book is contained in a work which must delight every man of education, and from which I have gained much information, — *Natural Theology considered with Reference to Lord Brougham's Discourse on that Subject*; by Thomas Turton, D.D., Regius Professor of Divinity in the University of Cambridge, and Dean of Peterborough. Cambridge, 1836. The Creator is a distinct being, to whom there is nothing "simile aut secundum," whose essence is incommunicable; and no created being has His attributes, though we speak of the Divine Mind. He is every where — has always existed — will always exist — and orders and sustains all things. His nature is past finding out; and, therefore, to attempt to conceive His nature, or to speak of Him except as speaking of His works and laws, is vain — and to think the highest created beings even approach His nature is absurd. In the words of Mr. Carmichael, — "There is no spirit in the universe but His incommunicable essence."

If Lord Brougham is deeply in error when he calls, as he does, the insensible change of particles during life "an entire destruction of the body," — "the body's death" and "dissolution," though organisation and life have not experienced the intermission of a moment, he is equally wrong when he derives a proof of the existence of something immaterial from the invariableness of our consciousness of identity. Not only does our memory often fail us, so that we cannot say whether we did or said certain things which others know was the fact; not only are we continually deceived in dreams, as having said and done what never was the fact, so that, as Mr. Wallace remarks, we frequently exclaim, "Did I really do so and so, or did I only dream it?" but insane people daily believe themselves to be others; and, after violent affections of the brain, people not unfrequently forget who they are, and believe themselves to be other persons. (See Gall, l. c. 8vo. t. iii. p. 122. sqq.) Nay, cases occur in which a man has the consciousness of two persons. As the brain, like all other organs of animal life, is double, and the operations of the two halves of the brain proceed like one, just as the double impressions on the eyes and ears are known only as one, so one side of the brain is sometimes diseased or injured to even a great amount, without impairment of the mind. But if their action is rendered discordant — not the action of one arrested, but thrown out of harmony with the other — or if they act alternately, we have the phenomena of two states of consciousness. "One of Gall's friends, a physician," says Dr. Spurzheim, "often complained that he could not think with the left side of his head; the right side was one inch higher than the left. Gall attended a gentleman who for three years heard peasants insulting him on his left side. He commonly discerned his derangement, and rectified his error; but if he took a little too much wine, or had a fit of fever, he always imagined there were voices abusing him. Tiedemann mentions a certain Moor who was alienated on one side of his brain, and observed his madness with the other.

"All monomaniacs have a complicated consciousnees. I saw in Dublin a lunatic who fancied himself the Duke of Wellington. He thought to have com-

brain;" and of memory, "his seat and *organ*, the back part of the brain."[t] This was the account of the faculties given by Arabian

manded in Spain, and to have gained the battle of Waterloo! yet at the same time he was a clever and excellent servant, did his service at table and in the house with great propriety. I saw him handing round at a table, where there was a large party, every thing with perfect order and decency, so that no guest could suspect his aberration.

"There are other sorts of remarkable cases which prove that consciousness is not always single. Mr. Combe (*System of Phrenology*, p. 108.) quotes from the *Medical Repository*, the case of a Miss R., in the United States, who naturally possessed a very good constitution, and arrived at adult age without having it impaired by disease. She possessed an excellent capacity, and enjoyed fair opportunities to acquire knowledge. Besides the domestic arts and social attainments, she had improved her mind by reading and conversation, and was versed in penmanship. Her memory was capacious, and stored with a copious stock of ideas. Unexpectedly, and without any forewarning, she fell into a profound sleep, which continued several hours beyond the ordinary term. On waking she was discovered to have lost every trait of acquired knowledge. Her memory was a tabula rasa. All vestiges both of words and things were obliterated and gone. It was found necessary for her to learn every thing again. She even acquired, by new efforts, the art of spelling, reading, writing, and calculating, and gradually became acquainted with the persons and objects around, like a being for the first time brought into the world. In these exercises she made considerable proficiency. But after a few months another fit of somnolency invaded her. On rousing from it, she found herself restored to the state she was before the first paroxysm, but was wholly ignorant of every event and occurrence that had befallen her afterwards. The former condition of her existence she called the old state, and the latter the new state; and she is as unconscious of her double character as two distinct persons are of their respective natures. During four years and upwards, she had undergone periodical transitions from one of these states to another. The alterations were always consequent upon a long and sound sleep. In her old state she possessed all her original knowledge; in her new state, only what she acquired since. If a gentleman or lady be introduced to her in the old state, or *vice versâ*, and so of all other matters, to know them satisfactorily, she must learn them in both states. In the old state she possesses fine powers of penmanship, while in the new she writes a poor awkward hand; having not had time or means to become expert. In January, 1816, both the lady and her family were able to conduct affairs without embarrassment. By quickly knowing whether she is in the old or new state, they regulate their intercourse, and govern themselves accordingly. The Rev. Timothy Alden of Meadville has drawn up a history of this curious case.

"I know the history of a noble family where a son had similar fits, accom-

[t] *Anatomy of Melancholy*, P. i. S. 1. Mem. 2. Subs. 7.

authors, as Gall remarks[u], and repeated with little variation, by the European writers of the middle ages." In the 13th century,

panied by a special memory; so that consciousness was double, one for the ordinary state, and the other for the fits.

"Dr. Devan read to the Royal Society of Edinburgh, in February, 1822, the history of a case, observed by Dr. Dyer of Aberdeen, in a girl, 16 years old, which lasted from 2d March to 11th June, 1815. The first symptom was an uncommon propensity to fall asleep in the evenings. This was followed by the habit of talking in her sleep on those occasions. One evening she fell asleep in this manner: imagining herself an episcopal clergyman, she went through the ceremony of baptising three children, and gave an appropriate prayer. Her mistress shook her by the shoulders, on which she awoke, and appeared unconscious of every thing, except that she had fallen asleep, of which she showed herself ashamed. She sometimes dressed herself and the children while in this state, or, as Miss L. called it, 'dead asleep;' answered questions put to her in such a manner as to show that she understood the question; but the answers were often, though not always, incongruous. One day in this state she sat at breakfast, with perfect correctness, with her eyes shut. She afterwards awoke with the child on her knees, and wondered how she got on her clothes. Sometimes the cold air awakened her; at other times she was seized with the affection whilst walking out with the children. She sang a hymn delightfully in this state; and, from a comparison which Dr. Dyer had an opportunity of making, it appeared incomparably better done than she could accomplish when awake. In the mean time a still more singular and interesting symptom began to make its appearance. The circumstances which occurred during the paroxysm were completely forgotten by her when the paroxysms were over, but were perfectly remarked during subsequent paroxysms. Her mistress said, that when in this stupor, on subsequent occasions, she told her what was said to her on the evening when she baptised the children. A depraved fellow servant, understanding that she wholly forgot every transaction that occurred during the fit, clandestinely introduced a young man into the house, who treated her with the utmost rudeness, whilst her fellow servant stopped her mouth with the bed-clothes, and otherwise overpowered a vigorous resistance which was made by her even during the influence of her complaint. Next day she had not the slightest recollection even of that transaction; nor did any person interested in her welfare know of it for several days, till she was in one of her paroxysms, when she related the whole fact to her mother. Next Sunday she was taken to church by her mistress while the paroxysm was on her. She shed tears during the sermon, particularly during the account given of the execution of three young men at Edinburgh, who had described, in their dying declarations, the dangerous steps with which

[u] 4to. vol. ii. p. 358., 8vo. t. ii. p. 353. See Avicenna, l. i. sect. 1. doctr. 6. cap. v. p. 25.

a head divided into regions according to these opinions was designed by Albert the Great, Bishop of Ratisbon[x]; and another was published by Petrus Montagnana, in 1491.[y] One was published at Venice, in 1562, by Ludovico Dolce, a Venetian, in a work upon strengthening and preserving memory[z]; and another at Bologna, in 1670, in a work styled *Apologia Fisonomica*, by

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their career of vice and infamy took its commencement. When she returned home, she recovered in a quarter of an hour, was quite amazed at the questions put to her about the church sermon, and denied that she had been to any such place; but next night, on being taken ill, she mentioned that she had been at church, repeated the words of the text, and, in Dr. Dyer's hearing, gave an accurate account of the tragical narrative of the three young men, by which her feelings had been so powerfully affected.

"The same phenomena present themselves when in the state of somnambulism produced by animal magnetism. It has been repeatedly observed that some magnetised persons acquire a new consciousness and memory during their magnetic sleep. When this state has subsided, all that passed in it is obliterated, and the recollection of the ordinary state is restored. If the magnetic sleep is recalled again, the memory of the circumstances which occurred in that state is restored, so that the individuals may be said to live in a state of divided or double consciousness." (Dr. Spurzheim, *Phren.* Am. ed. p. 78. sqq.) See Gall on Personality (*moi*), 8vo. t. ii. p. 401. sqq.

[x] In the *Tesorretto* of Brunetto Latini, the preceptor of Dante, published in that century, the doctrine is taught in rhyme:—

Nel capo son tre celle,
Ed io dirò di quelle,
Davanti è lo intelletto
E là forza d' apprendere
Quello che puote intendere.
In mezzo è la ragione
E la discrezione
Che scherne buono e male.
E lo terno e l' iguale
Dirietro sta con gloria
La valente memoria,
Che ricordo e retiene
Quello ch' in essa viene.

[y] Gall, 4to. vol. ii. p. 358. sq., 8vo. t. ii. p. 354. sq., where as many historical details are given as the greatest detractor from Gall's originality could wish.

[z] A friend presented me with this book:—*Dialogo di* M. Ludovico Dolce, *Nel quale si ragiona del modo di accrescere e conservare la memoria.* In Venetia.

Ghiradelli Bolognonese. In the British Museum I have seen a chart of the universe and the elements of all sciences, and in it a large head so delineated is conspicuous. It was published at Rome so late as 1632, and, what is singular, engraved at Antwerp by one Theodore Galleus, and the head is really a good family likeness of Dr. Gall, who, however, was born at Tiefenbrunn in Suabia, between Stuttgard and the Rhine, March 9. 1758.[a]

[a] Notice Historique sur le Docteur Gall, par M. Fossati, M.D. *Journal de la Société Phrénologique de Paris*, t. i. 1832.

It is remarkable that Aristotle, in his *Physiognomy*, though he gives a number of ridiculous signs of character from the face and numerous parts of the body, gives three only from the cranium; but that these are in strict accordance with the phrenology of Gall, who admitted of no deduction of intellectual or moral character from the developments of the face, but from those of the cranium only.* "Those who have a large head, are sagacious — are like dogs; those who have a small head, are stupid — are like asses; those who have a conical head, have no shame — are like birds with curved claws."

Head given by Dolce, 1562. It is copied into the *Edin. Phrenolog. Journ.* vol. ii. No. 7.

Μεγάλην οἱ τὴν κεφαλὴν ἔχοντες, αἰσθητικοί· ἀναφέρεται ἐπὶ τοὺς κύνας· οἱ δὲ μικρὰν, ἀναίσθητοι· ἀναφέρεται ἐπὶ τοὺς ὄνους. οἱ τὰς κεφαλὰς φοξοὶ, ἀναιδεῖς· ἀναφέρεται ἐπὶ τοὺς γαμψώνυχας.— *De Physiognomiâ*, cap. vi.

It is no less remarkable that one of each of these points is spoken of by each of the three greatest poets.

Milton distinguishes man from Eve and all the other beings in Eden, above whom he was intended to rule through the force of intellect, by his spacious forehead:

> "His fair *large front* and eye sublime declare
> Absolute rule." *Paradise Lost*, b. iv.

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* l. c. 4to. vol. iv. p. 234. sqq., 8vo. t. v. p. 429. sqq. He of course allows pathognomy, or the art of judging of the state of the feelings by the expression of the countenance in action, to be real; and he mentions a number of curious facts illustrative of the coincidence of pathognomy with the seat of the organs. His original genius is very conspicuous on this subject.

It is, however, more than probable that the different parts of the brain have different offices. Its faculties are so various, that it is impossible to imagine them possessed by the same portion. The faculty for melody is perfectly different from the love of offspring. If to suppose all parts of the brain are organs for all faculties is difficult, the difficulty appears greater on reflecting that in that case the whole brain would be concerned in every act and feeling, or, if the whole brain is not thus constantly at work at all things, that different parts would perform the very same offices at different times, each part working in every kind of mental act and feeling in its turn. Neither does the brain perform merely one thing, as the whole liver performs the secretion of merely one fluid — bile; nor is its structure the same throughout, like that of the liver.

The best authors hold that its various parts have various offices[b], and Gall *proves* that they have.

Shakspeare makes Caliban say —

> " I will have none on't: we shall lose our time,
> And all be turned to barnacles, or to apes
> With foreheads *villainous* low. *Tempest*, Act iv. sc. 1.

Homer gives the basest fellow who went to Troy, a conical head — a miserable development of the seat of the moral sentiments: —

> Θερσίτης . . .
> . . . αἴσχιστος δέ ἀνὴρ ὑπὸ Ἴλιον ἦλθε.
> Φοξὸς ἔην κεφαλὴν.
>
> *Ilias*, B.

[b] " The brain is a very complicated organ," says Bonnet, " or rather an *assemblage of very different organs.*" (*Palingénésie*, t. i. p. 334.) Tissot contends that *every* perception has *different* fibres. (*Œuvres*, t. iii. p. 33.) Cuvier says, that " *certain* parts of the brain in all classes of animals are large or small according to certain qualities of the animals." (*Anatomie Comparée*, t. ii.) Sömmerring trusts that we shall one day find the *particular seats of the different* orders of *ideas*. " Let the timid, therefore, take courage," says Dr. Georget, in his admirable work upon the nervous system, " and, after the example of such high authorities, fear not to commit the unpardonable crime of innovation, of passing for cranioscopists, by admitting the plurality of the faculties and mental organs of the brain, or at least by daring to examine the subject." (*De la Physiologie du Système Nerveux, et specialement du Cerveau*, t. i. p. 126.) Gall's successful reply to some very unjust observations made in this work, will be found in his 8vo. edit. t. v. p. 488. sqq. Dr. Vimont repeats these, apparently in ignorance that Gall had fully replied in his small work; and censures Gall for having incorrectly said that Bonnet considered every cerebral fibre as having a distinct function. Now Bonnet's words really are, — " I thus consider every

If the old course, recommended by Mr. Dugald Stewart, of investigating the mind by attending to the subjects of our own consciousness, had been persevered in, the science of mind would have remained stationary for ever.[c] Our powers and feelings are distributed in such various degrees, and the external circumstances which have acted upon them are so various, that every man, judging from himself only, would draw up a different account of the human mind; as different from the attempts of all others, as the representations of the human face and head would be, if every painter were to execute his own likeness only. The account would be as inaccurate as if an individual were to determine the bodily powers and susceptibilities of the operation of agents by his own. Unquestionably much must be learned by observing the workings of our minds, and much can be learned

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sensible fibre as a very little organ with its own functions." "The brain contains a prodigious number of organs *infinitely small*, appropriated to sentiment and thought."

[c] Although Mr. Dugald Stewart declares that in his own inquiries he has "aimed at nothing more than to ascertain, in the first place, the laws of our constitution, as far as they can be discovered by attention to the subjects of our own consciousness;" (*Essays*, Preliminary Dissertation, p. 2.) "that the whole of a philosopher's life, if he spends it to any purpose, is one continued series of experiments on his own faculties and powers;" (p. 40.) and that "the structure of the mind (whatever collateral aids may be derived from observing the varieties of genius in our fellow creatures) is accessible to those only who can retire into the deepest recesses of their own internal frame;" yet he adds, "even to those, presenting, along with the generic attributes of the race, many of the specific peculiarities of the individual," (*Elements*, vol. ii. p. 513.) and has really the following passages in the forty-second and forty-third pages of the *Essays*. — "To counterbalance the advantages which this science of mind lies under, in consequence of its slender stock of experiments, made directly and intentionally on the minds of our fellow creatures, human life exhibits to our observation a boundless variety, both of intellectual and moral phenomena, by a diligent study of which we may ascertain almost every point that we could wish to investigate, if we had experiments at our command." "Savage society, and all the different modes of civilisation; the different callings of individuals, whether liberal or mechanical; the prejudiced clown, the factitious man of fashion; the varying phases of character, from infancy to old age; the prodigies effected by human art, in all the objects around us, laws, government, commerce, religion; but above all, the records of thought preserved in those volumes which fill our libraries; — what are they but experiments, by which nature illustrates, for our instruction, on her own grand scale, the varied range of many intellectual faculties, and the omnipotence of education in fashioning the mind."

in no other way; just as we may learn much of the external form of the human body by looking at ourselves, and cannot learn what are the feelings of hunger and thirst, heat and cold, except from our own consciousness. But it is only by extensive observation of others, of different sexes, ages, races, education, occupations, and habits, in addition to the study of ourselves, that this knowledge is to be acquired. Nor would much progress have been made without the discovery — that strength of individual talent and disposition was associated with proportionate development of particular portions of the brain. By this remark, confirmed by the opposite observation of deficient development of the same portions of the brain being accompanied by deficiency of talent or disposition, the existence of particular faculties was firmly established; and indeed Gall discovered them by observing persons conspicuous in some mental points to have certain portions of the head extremely large. I did but allude to craniology while detailing Gall's account of the mind, because the arrangement may be perfectly accurate, although craniology be false; nor when speaking of the brain as the organ of the mind, because that fact also is independent of Gall's system. But, if the account of the mind, the use of the brain, and the development of the brain, generally observed by that of the cranium — by craniology, be now viewed together, they will all be seen mutually and beautifully to confirm each other.

Much ignorant invective, but no argument, has been written against the doctrine; nor a *single fact* adduced in opposition to it. We are presented with a simple statement — that constant strength of certain parts of the mind is accompanied by strong development of certain parts of the brain, and, *consequently*, of the skull, except in disease and old age; and deficient development of certain parts of the brain, and, *consequently*, of the skull, accompanied by deficient strength of certain parts of the mind. The truth must be ascertained, not by speculating, quibbling, and abusing, not by giving improper way to the lower feelings of our nature, but by observing whether this is the case; and every one has it in his power to make the necessary observations. Those who pretend to have facts to offer in objection, must first be so well acquainted with *craniology* as to be able to judge accurately of the development which they adduce, and have carefully ascertained the character and exact talents of the individual whom they fancy to be an exception. Yet accounts the most absurd, and the most remote from truth in

these particulars, are uttered and printed every day, even by those who assume the character of *scientific* men. Inquirers, however, must not expect always to find the converse of the statement verified, — to find strength of development always attended by strength of certain parts of the mind; nor deficiency of the manifestations of certain parts of the mind always attended by deficient development. Because the development of the head may arise from other causes than brain, or the quality of the brain may not be healthy; and, on the other hand, deficiency of the manifestations of a part of the mind may arise from mere want of excitement, or from disease. The head may be large, generally or locally, from fluid, morbid growth of bone, &c.; or the brain, though the cause of the size, may be of bad quality from original fault of structure, from subsequent disease, or from old age. But the existence of disease is generally known, and old age must be evident. Again, defective manifestations of a part of the mind from mere want of excitement rarely occurs except in regard to the intellectual powers; for external circumstances almost always exist around sufficient for the play of the feelings. Thus, although any phrenologist may always without fear assert positively of the head from constant positive exhibitions of the mind, and always fearlessly assert negatively of the mind from negative exhibitions of the head; he would not assert respecting the mind from positive exhibitions of the head, nor respecting the head from negative exhibitions of the mind, without certain provisions, viz. that the size of the head depends upon healthy brain, and the deficiency of mind arises from no want of excitement, or from disease. Yet, in the far greater number of instances, the development of the head agrees with the mind. In the greater number of those in which it does not, the probability of the want of agreement is evident; and in the rest, the phrenologist cannot be wrong, because he will never assert from positive development of the head, nor from negative manifestation of the mind. Even in unsoundness of mind, the character generally agrees with the development; the parts of the mind that may remain sound, generally manifest themselves according to the development of the head; and those faculties which are diseased, are usually excited in proportion to the development of the corresponding parts of the head.[d]

[d] Let the antiphrenologist get over the diagnosis of Gall in his visit to some Prussian prisons (l. c. 4to. vol. iv. p. 369. sqq., 8vo. t. vi. p. 476. sqq.), and of

The exact situation of the organs can be learnt from delineations or marked heads only. I shall therefore confine myself to Gall's general remarks. 1st. The organs of the faculties or qualities common to man and brutes, are placed in parts of the brain common to man and brutes, — at the inferior-posterior, the posterior-inferior, and inferior-anterior parts of the brain; *v. c.* of the instinct of propagation, the love of offspring, the instinct of self-defence, of appropriating, of stratagem, &c. 2dly. Those which belong to man exclusively, and form the barrier between man and brutes, are placed in parts of the brain not possessed by brutes, *viz.* the anterior-superior and superior-anterior of the front: *v. c.* of comparative sagacity, causality, wit, poetic talent, and the disposition to religious feelings. 3dly. The more indispensable a quality, or faculty, the nearer are its organs placed to the base of the brain, or median line. The first and most indispensable — the instinct of propagation — lies nearest the base; that of the love of offspring follows. The organ of the sense of localities is more indispensable than that of the sense of tones or numbers; accordingly the former is situated nearer the median line than the two latter. 4thly. The organs of fundamental qualities and faculties which mutually assist each other, are placed near to each other; *v. c.* the love of propagation and of offspring, of self-defence and the instinct to destroy life, of tones and numbers. 5thly. The organs of analogous fundamental qualities and faculties are equally placed near each other: *v. c.* the organs of the relations of places, colours, tones, and numbers are placed in the same line, as well as the organs of the superior faculties, and the organs of the inferior propensities.[e]

Although the arrangement of the organs is so beautiful, we must not imagine that Gall mapped out the head at pleasure, according to preconceived notions. He discovered one organ after another, just as it might happen, and marked down its situation and size upon the cranium; and after all left several spots

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Mr. Combe, in his visit to the Richmond Lunatic Asylum, Dublin, and the prisons and lunatic asylums of Newcastle. (Dr. Combe *On Mental Derangement:* and *Ed. Phr. Journal*, No. xlvi.) On Idiotism with no defect of development, see Gall, l. c. 8vo. t. vi. p. 50.

[e] Gall, l. c. 4to. vol. iii. p. 78. sq., and 8vo. t. iii. p. 208. sqq. So much less have the writings of Gall than those of Dr. Spurzheim been studied in Edinburgh, that Mr. Scott published these two last principles as his own; and they thus stand, with great praise, in Mr. Combe's *System of Phrenology*, p. 534. sqq.

blank, which others have filled with faculties corresponding with those around. The organs are represented, in the engraved heads which he published, as so many prominences ; because each is just as it showed itself to him in single instances where it was extraordinarily developed. This habit of representation for distinctness and fidelity of form and size, and that of speaking of individual parts as prominent, gave origin to the vulgar notion of bumps, and those ignorant views which still disgust us in persons who should know better. Often one organ became known to him situated very remotely from the organ last discovered. The set of organs discovered by him turned out as it is, and a strong argument is thus afforded of the truth of his system, He viewed a thousand times what he had remarked, before he was aware of the great general truths just mentioned.

"All must be struck," says he, "with the profound wisdom which shines forth in the arrangement and successive order of the organs. This connection is, in my eyes, one of the most important proofs of the truth of my discoveries. I defy those who attribute my determination of the fundamental faculties and of the seat of their organs to caprice or arbitrary choice, to possess a tenth part of the talent necessary for the most obscure presentiment of this beautiful arrangement ; once discovered, it displays the hand of God, whom we cannot cease to adore with wonder increasing as his works become more disclosed to our eyes."[f]

[f] l. c. 8vo. t. iii. p. 210. sq. See also 4to. vol. iii. p. 80. Mr. Combe (l. c. p. 536.) presents these beautiful remarks as Mr. Scott's, with no other mention of Gall than that the *system* must thus be the work of nature, and not "of Drs. Gall and Spurzheim." Dr. S. divided all the faculties, after the ancients, into effective and intellectual; and the former again into propensities and sentiments ; the latter into perceptive and reflective. (l. c. p. 131.) For this he has been said to have "infused philosophy and system into the facts brought to light by observation," (*Ed. Phr. Journ.* vol. v.) — to possess a power of arrangement which throws light upon every subject." (*Star of Brunswick*, quoted in his *Biography*, published at Boston, p. 99.) Gall, again, was declared to have no such powers of systematising. What is the truth? Gall disliked artificial systematic division and subdivision, and that justly. His very order of examining is as great a classification as nature will admit. His order was, "as much as possible, that which the Author of nature observes in the gradual *perfectionnement* of animals." (l. c. 4to. t. iii. p. vi.) Beyond the order which he followed in his writings, nothing could be done ; and, as Mr. G. Combe truly says (*Preliminary Dissertation* to the *Phr. Journal*, p. 25.), "as soon as observation had brought to light the great body of facts, and the functions of

Gall followed this natural order of the faculties. "I conform to the order which exists in considering the inclinations or inferior

losophy of the human mind presented itself almost spontaneously to view." Gall saw nothing satisfactory in Dr. S.'s classification. "The most natural and philosophical order," says Gall, "must be that which nature has observed in the successive arrangement of the cerebral parts. But M. Spurzheim begins by establishing new divisions of the faculties of the mind." "The philosophical spirit of M. Spurzheim shines in divisions, subdivisions, sub-subdivisions, &c.; and this is what he calls infusing more philosophy into the physiology of the brain, than I had the ambition of introducing. By these divisions he has imposed on himself a constraint which totally inverts the gradual succession of the organs. He is forced to jump from one region of the brain to another; from the disposition to theft, to destruction; from this to construction; from circumspection, to benevolence; from benevolence, by a great effort, to veneration; from supernaturality (he is using Spurzheim's terms), he comes to the external surface part of the forehead, thence to imitation; from imitation, to the external senses! Then he retires to the brain towards the frontal region — there again he treats every thing *péle-méle,* all in a manner opposite to nature; — a perfect monstrosity, which one would believe to be invented with the design of rendering the study impossible. The propensities and sentiments, and often the intellectual faculties, are so confounded together, that it is hardly possible to discover the characteristic signs which distinguish one from another. What more reason is there to place constructiveness among the propensities, than melody, benevolence, and imitation? Are not amativeness, philoprogenitiveness, inhabitiveness, attachment, courage, as much sentiments as self-love, love of approbation, veneration, &c.? In what sense are perseverance, circumspection, imitation, sentiments? With what propriety does he exclude imitation, wit, ideality or poetry, circumspection, secretiveness, constructiveness, from the intellectual faculties?"* Wit and imitation were originally placed by Dr. S. among the intellectual faculties, and then removed to the sentiments in later editions. The Feelings were divided into superior and inferior, and those common to brutes and man and those peculiar to man; and imitation was ranged with the superior and peculiar to man! but, no sooner has he done this, than he admits imitation to exist among many tribes of brutes! (*Phr.* Am. ed. vol. i. p. 257.) Wit, the organ of which is amidst the intellectual, he dislodges for mirthfulness, which he calls a superior sentiment *peculiar to man,* and given to "render him *merry and gay*"! — to be "as gay as a *lark,*" however, I suppose, and "merry as a *kitten.*" He forgets that *mirthfulness* always implies noise:"

"Far from all resort of mirth,
Save the cricket on the hearth."

His opinions on this faculty appear to me most extraordinary. In one of his works (*Essai Philosophique*), he classed benevolence with those peculiar to man;

* l. c. 4to. vol. iii. p. xxvi. sqq. Dr. Vimont also exposes the faults of Dr. S.'s classification. (l. c. t. ii. p. 106. sqq.)

qualities; then those which have more and more nobleness; and end with the highest sentiment—that which leads us to reverence the divinity."[g]

in another allows it to brutes (*Phr.* Am. ed.); and, having subdivided sentiments into superior and inferior and finished the inferior, saying he has "gone over the affective faculties which are common to men and animals," he begins with the superior, and says the first (benevolence) "cannot be entirely denied" to brutes. (p. 222.) He arranges the five external senses with the intellectual faculties;—"the triumph of his new arrangement," as Gall severely terms it. Dr. S.'s classification had been devised and published ten years before by Bischoff. Yes; Dr. S., in all his works and editions, gives his arrangement without a hint that any one had classed the faculties before; whereas in the work already quoted (*Exposition de la Doctrine de Gall*, traduite de la seconde édition d'Allemand, 1806), Bischoff's division into three orders will be found,—the first containing the propensities and sentiments; the second, the perceptive faculties; and the third, the intellectual. Three faculties are in the second class, and one in the third, which Dr. S. puts in others; but he himself shifted some occasionally, and the difference is insignificant; and Dr. S.'s invariable silence as to this arrangement, while his own forms a conspicuous part of nearly all his books, is a fact in complete harmony with the rest of his conduct. "I conceive it possible to divide them" (the faculties), says Dr. S., "and to establish a new classification;" "and I established a new division of the mental operations." (*Phren.* Amer. edit. vol. i. p. 129. sq.) In his first London edition, he most innocently says, "I am now led to think that the objects which are still to be added to our large work must assume a more scientific arrangement, and be considered in a more philosophic manner than Dr. Gall has been accustomed to do in his lectures." (p. vii.) Then follows his most trifling variety of Bischoff's arrangement, to which he no where alludes, though he proves his acquaintance with the book in his notes to the *Foreign Quarterly*, p. 62. The following is Gall's opinion of classification:—"Every one may arrange the moral qualities and intellectual faculties according to his own views of them. They may be divided into sentiments, propensities, talents, intellectual faculties;—pride, for example, and vanity, would be sentiments; the instinct of propagation, the love of offspring, propensities; music, mechanics, would be talents; comparative sagacity would belong to the intellectual faculties. But there is frequently embarrassment in rigorously fixing the bounds of each division. The intellectual faculties and talents, when their organs are very active, manifest themselves with desire, propensity, and passion; the sentiments and propensities have also their judgment, their taste, their imagination, their memory and recollection. The division into qualities and faculties common to man and brutes, and faculties and qualities peculiar to man, is, I confess, of great value in a philosophic point of view; but," "when the most careful observer dares not decide where the faculties of the brute cease, and those of man begin, this division cannot be considered satisfactory. The best division, in my opinion, is into fundamental qua-

[g] l. c. 8vo. t. iii. p. 224.; also, 4to. vol. iii. p. 85.

If Gall's is the only satisfactory account of the mental faculties, and to me it certainly appears so, this alone is a proof of

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lities or faculties, and general attributes of these qualities and faculties. In this division, the fruits of the labours of my predecessors are preserved, and, while we avail ourselves of them, we establish the true theory of the primitive and fundamental instincts, qualities, and faculties of man and brutes." (l. c. 4to. t. iv. p. 344. sq., 8vo. vol. vi. p. 433. sq.)

Dr. Spurzheim, in his fondness for changing his names, his arrangement, and his numbering of the organs, introduced confusion without advancing knowledge. To prove his speculative spirit, I may mention that, instead of giving the origin of any of his asserted discoveries, as Gall did, and adding a host of examples, he tells us, in regard to the organ of inhabitiveness, only that a gentleman much attached to his house had a particular spot of his head hotter than any other; and in regard to the organs of hope, marvellousness, conscientiousness, size, weight, order, time, he neither tells how he discovered them, nor adduces a single proof. Gall was too much of a philosopher to wish others to examine a mere assertion.

But, in regard to all the organs discovered by Gall, except that of colour, Dr. S. gives the circumstances which led to the discovery, and a certain number of individual facts; though but a very small number of those related by Gall. "He has changed the names," says Gall, "but treated the organs according to my principles; yet in so hasty and feeble a manner, that this part of my doctrine would be deplorable, if it were not established on a better foundation." (l. c. 4to. vol. iii. Preface; a part which every body should read, for its exposure and demolition of Dr. S.'s unjust and weak attempts.) His own alleged discoveries may be real; but the remarkable circumstance I have mentioned tends to create a suspicion that he reasoned himself into a belief of certain faculties, and gave them localities according to their nature; having learnt from Gall where "perceptive" and where "reflective faculties," where "sentiments" and where "propensities," to use his own language, reside. Localisation, after Gall's discoveries, was easy, especially as Gall had not mapped out the whole head, but left blanks where he possessed no facts.

He changed even the situation and extent of organs in his last plate. The space allotted by him to marvellousness was originally between wit, imitation, hope, and ideality; now it is more than twice its former size, and placed between these four and veneration. Covetiveness was placed by Gall, and admitted by Dr. Spurzheim, before cunning and under ideality; now it is over cunning, and between ideality and cautiousness. Ideality in his first edition was chiefly above covetiveness and before circumspection; now it is above constructiveness, and a large organ stands between it and covetiveness. Yet he declares, that, "though marked busts or plates may be *numbered* differently, the places of the respective organs, once considered as established, have never been altered." (*Phr.* Amer. ed. vol. i. p. 136.) If he is right as to the new situation of the organ of covetiveness, all the observations which led Gall to its discovery, and originally convinced Dr. S., fall to the ground. Dr. S., in the *Notes* (p. 62.), says, "that he has been occupied for three years with showing the regularity of the cerebral portions, and with specifying the individual organs

the truth of his organology. For such an account could not have resulted from imagination; and observation, unaided by reference

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and their boundaries;" "an additional discovery, of which Dr. Gall died in ignorance." Yet Gall, in both his works, refers to the individual convolutions which he regards as the organs of the individual faculties. Dr. S., in these (*Notes* p. 63.), then says, "that it was he himself who directed phrenologists to attend to the individual regions of the head, in reference to the three lobes of the brain, and to the three regions of the animal propensities, the human sentiments (among which he puts some not exclusively human), and intellectual faculties (but he admits the five senses among these), rather than to the protuberances and depressions, to which Dr. Gall attached himself almost exclusively." Now Gall over and over again speaks of the development of regions (l. c. 4to. vol. iii. p. 85., 8vo. t. iii. p. 221. sqq.; 4to. vol. ii. p. 400. sq., 8vo. t. ii. p. 423. sqq.; 4to. vol. iv. p. 13. sq., 8vo. t. iv. p. 378.; 4to. vol. iv. p. 161. sq., 8vo. t. v. p. 191. sqq.), and expressly advises that the size of the whole head should be first observed; then that of the frontal, occipital, lateral, and sincipital regions; and lastly the subdivisions of these regions; and "it will be soon found," says he, "that the best developed organs do not form any of the bumps of the antiphrenological buffoons, nor prominences like an egg or your fist." (l. c. 8vo. t. iii. p. 221. sqq.)

Dr. S. also says (*Notes*, p. 63.), that "Gall mostly confined himself to the comparison of talents, character, and certain modes of acting, with individual cerebral portions;" and I have heard it often asserted that we owe to Dr. S. only our knowledge of the mutual influence of organs. But Gall insisted strongly upon this, though he left the endless working out of the self-evident effects of the varied proportions of organs to us all. (l. c. 4to. vol. iii. p. 192., 8vo. t. iv. p. 243.; 4to. vol. iii. p. 298. sq., 8vo. t. iv. p. 253. sq.; 4to. vol. iv. p. 256. sq., 8vo. t. v. p. 374. sq., 8vo. t. ii. p. 318. sq.) So, in regard to mania, the substance of all that Dr. S. has written upon it may be found in Gall. (l. c. 4to. vol. ii. iii. iv., 8vo. t. i. p. 370. sq., and t. i. ii. iii. iv. v. *passim.*)

He illustrated and applied Gall's philosophy on the subject of morals, education, &c.; but, when he is satisfactory, I see nothing more than is to be found, expressed far more concisely, powerfully, and elegantly in the writings of Gall.

The merit of Dr. Spurzheim was that of an able and persevering pupil of Gall. It is possible that, having worked under Gall's direction so long, after he left his great master he discovered a mechanical anatomical point or two—though I know not that he did. It is possible that he discovered the organs of three faculties, which Gall believed to exist — time, and order, and conscientiousness. He had, however, only to look for the spaces left vacant by Gall among the organs of the perceptive faculties to locate time and order; and he no doubt remembered, as all Gall's acquaintance do, that Gall always said that the organ of time would be found close to that of tune, and had actually left a space there. It is possible, that he established a few more faculties and their organs — weight, size, and hope. But I am not yet certain of the two former. Hope I do not believe to be a primitive faculty. I believe, with Gall, that every

to development, never produced much that is satisfactory in metaphysics. It was in fact derived from studying the organisation.

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faculty desires its gratification, and that its prospect of this, or hope, is regulated by the degree of circumspection and of the intellectual faculties.* He of course had only to place conscientiousness and hope in the spaces left vacant by Gall among the moral sentiments. In regard to marvellousness, Gall had assigned that part of the brain to the disposition to see visions; but regarded these as only an excess of activity of some fundamental power, and had often discussed with Dr. S. the possibility of a faculty for wonder; though he refrained from publishing mere speculations. (l. c. 4to. t. iii. p. xxiv., 8vo. vol. v. p. 345.) Then, as to the organ of inhabitiveness, we must remember that Gall left the space vacant, and pointed out that animals inclined to inhabit high places had the part immediately above it large; — that Gall taught the existence of a faculty inclining to particular habitation, and placed that faculty in the region where Dr. Spurzheim has fixed his organ of inhabitiveness. If Dr. S. is correct, he has cleared up what Gall considered unsettled. But Dr. S. could not consider himself certain, as in his last edition he begged phrenologists to make observations on the point; and the Edinburgh phrenologists actually give to that part the faculty of what they call concentrativeness — the faculty of "maintaining two or more powers in simultaneous and combined activity, so that they may be directed towards one object." (Dr. S. *Phr.*, Amer. ed. vol. i. p. 169.) They attempt to reconcile matters by seeing no inconsistency in both views. To this Dr. S. cannot agree, and he satirically says, that, with all possible deference to Mr. Combe's acuteness and greater development of the organ of concentrativeness, he cannot believe the inclination to inhabit a particular spot, and the power of keeping two or more faculties in simultaneous action, to be the same. The publication of such speculations, such deviations from rigid observation — from true inductive philosophy — it was that distressed Gall in both Dr. S. and some Edinburgh phrenologists.

Dr. S. differed from Gall on certain points regarding the various faculties which he admitted; but I confess that, so far from improvements, I think that his opinions in general are unsatisfactory or incorrect, and exhibit subtlety rather than depth, and an immeasurably less powerful and philosophic mind than that

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* "Most authors confound the affections with the passions. By passion I mean the highest degree of voluntary or involuntary activity of any fundamental force. Every passion implies a particular organ; but this organ produces the passion of its function, only when at the maximum of its activity. It is different with the affections. In the passions, the organs are active, exalted in their fundamental function; in the affections, on the contrary, the organs are passive, modified, seized in a particular manner, agreeable or disagreeable. Shame, fear, anguish, sorrow, despair, jealousy, anger, joy, ecstasy, &c., are involuntary sensations, passive seizures, either of our nervous system, of one organ, or of the whole of the brain. There consequently can be no peculiar organ for joy, for sorrow, for despair or discouragement, for *hope*, nor for any affection whatever." (Gall, l. c. 8vo. t. vi. p. 431. sq.)

He never once allowed himself to speculate, having early learnt the fallacy of *à priori* reasoning; but abandoned himself entirely to observation.

Gall discovered each organ and its faculty either by meeting with individuals very remarkable for the latter, so that he was led to examine their heads; or by noticing a peculiarity of formation in the head which induced him to ascertain their talents and character. He did not examine remarkable persons according to the views entertained of the faculties by metaphysicians; but according to points in which the world at large pronounced them remarkable,—accordingly as they were courageous, avaricious, kind-hearted, or excelled as poets, mimics, linguists, philosophers. He would never have made his discoveries, had he not met with persons remarkable in these respects. Sometimes the relation between the remarkable faculty or quality and the local development was tolerably obvious, but generally he had to make numerous observations before he found himself right. After having found two individuals remarkable in the same point of character, and cast their heads, he sometimes examined the casts daily for months before he could discover the precise spot in which they agreed. The discovery being now made, a good organologist will give judgments upon character which must astonish, and incontestably prove the truth of phrenology; but the difficulty of making the discovery when all was utter darkness must have been extreme.[h] The indefatigable industry of Gall, during the whole of a long life, constantly observing all persons he met with, and searching after all who were in any mental respect remark-

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of Gall. Dr. Lélut has just published a work which he calls *Qu'est ce que la Phrénologie?* and says that Gall's psychological doctrine is "souvent heureusement corrigée, mais quelquefois aussi gâtée par Spurzheim ou par la phrénologie." (p. 398.) Yet he mentions ten points of deterioration by Dr. S., and but four of improvement, and among these four, two appear to me improvements only because Dr. Lélut is in error as to Gall's opinions.

[h] "I had innumerable difficulties to overcome; as long as a quality or faculty, or even its organ, was not discovered, I was in the deepest ignorance. I never had the slightest idea of what I should at length discover, nor where I should find the organ. A large number of facts was requisite to put me in their way. How often have I not been obliged to reject, after years, what had appeared to me well established! Often I was tempted to give up all inquiries of this nature, and to declare, with my predecessors, that it is impossible to discover the traces of the operations of the soul." (l. c. 4to. vol. iii. p. 77. sq. See also 8vo. t. iii. p. 206. sqq.)

able, travelling as he did to most of the prisons, mad-houses, and hospitals of the Continent; examining the habits and heads of brutes innumerable for comparison; and engaging M. Niklas, Dr. Spurzheim, and others, for a pecuniary consideration, to work under him and examine points for him, in the way of reading, dissecting, casting, moulding, and observing living persons, is astonishing[k]; and the success and importance of his researches will, I am satisfied, ensure him a place among the greatest names of the human race, although, like every other great discoverer and benefactor, he has been loaded with ridicule and abuse.[l] His great anatomical discoveries were derided, and, when this was possible no longer, given falsely to his predecessors, or contemporaries, or have been given even to later writers. Some have been announced by others, lately, as new, and are even contended for by different individuals. Few anatomists and physiologists have any idea of the errors as to facts and of the poverty of argument displayed by Cuvier, Tiedemann, Pinel, Esquirol,

[k] l. c. 8vo. t. iii. p. 137. sqq. 172. sq. 206. sq.

[l] Mr. (now Lord) Jeffrey, in a violent article in his *Edinburgh Review* for 1815, after glancing at an English work by Dr. Spurzheim, wrote off-hand an article against it, and declared "the whole doctrines, anatomical, physiological, and physiognomical, to be a piece of thorough quackery from beginning to end,"—"there being nothing so impossible but *mountebanks* will undertake, nothing so incredible but they will affirm," — "that to enter on a particular refutation, would be to insult the understanding of readers," as Gall's opinion "on the *functions in general* of man, and on his intellectual faculties in particular, are a collection of mere absurdities, without truth, connection, or consistency; an incoherent rhapsody, which nothing could have induced any man to have presented to the public under a pretence of instructing them, but absolute insanity, gross ignorance, or matchless assurance." "Such is the trash," he continued, "the despicable trumpery, which men, calling themselves scientific inquirers, have the impudence gravely to present to physiologists of the nineteenth century as specimens of reasoning and induction." — A clergyman, afterwards chaplain to a Royal Hospital, and now a dignitary, at the same time wrote an article in a less violent strain in the *Quarterly Review*, in which he styled phrenology "sheer nonsense, and Dr. Spurzheim a fool." (No. xxv.) A year before they had called Gall "an ignorant and interested quack;" and *Blackwood's Magazine*, in April, 1817, foretold that "phrenology would be forgotten as soon as Dr. Spurzheim left Edinburgh:" just as, when Der Freischutz was first played in London, the *Literary Gazette*, which, like so many other learned periodicals, has always spurned phrenology, pronounced that, if the Germans were delighted with such music, they must be more easily satisfied than Englishmen; that it was "extremely ineffective;" and they "much doubted if there be a single air in it likely to become popular." (July 24. 1824. No. 392.)

Richerand, Carus, Rudolphi, Serres, &c., and would be amply repaid for the trouble of reading their exposure by Gall in various parts of his works, especially in his sixth octavo volume. Whoever knew him must have admired his profundity and candour, and the extent and variety of his knowledge, and been delighted with his perfect integrity and true philosophy of character, and the gentleness and elegance of his manners. [m]

[m] Nothing could demonstrate more the unsuspecting and kind nature of Gall than his affixing the name of Dr. Spurzheim with his own to his great work. He was the discoverer, and first published on his discoveries in 1798. He first lectured in 1796, when 40 years of age; Dr. S. being but 20 and a student. He continued to lecture on his discoveries till 1802, when the absurdity of Austria forbade all lectures in Vienna without permission. Gall knew the measure was levelled at himself; and, scorning to ask permission, left Vienna. Dr. S., who was tutor in the family of a nobleman attended by Gall, after having finished his medical studies, had become one of Gall's pupils, and was the only one among them all who was willing to leave Vienna with him. Gall saw his good intellectual development and his firmness, and engaged him as his secretary, dissector, &c. Though we all know how beautifully Dr. S. dissected the brain, Gall assured me that he was very long in teaching Dr. S. to dissect it; and that Dr. S.'s clumsiness cost him no little in broken casts, models, &c. Dr. S. thus worked hard at phrenology: but he worked under Gall's direction, and Gall smiled at the idea that two persons, the one twenty years older than the other, and the entire discoverer of a subject on which he had laboured for thirty years, and paying the other for his labour, could work at the same points, unless the one were directed by the other, — not at different branches of the same subject; and especially he smiled at Dr. S.'s having made discoveries, except as far as he found things which he was directed by Gall to ascertain. The whole work was Gall's. Every line, he informed me, was his sole composition. The very style shows this. The work is clear, flowing, full, at once rigidly philosophical and rich with profound thoughts and glowing illustrations. I never take it up without finding something fresh, and feeling that I am with one of that band of mighty minds to which Bacon, Milton, Shakspeare, &c. belonged. It speaks for itself and is totally different from Dr. S.'s; and yet in the preface, p. xlii, he was so good to Dr. S. as to mention the very composition and diction in the plural number, though self-evidently referrible in all cases to no more than one person. He conceived that all Europe knew him as the author of the discoveries; and he wished to be of service to Dr. S., who had shown good abilities and been industrious; and who, being twenty years younger, would, he hoped, prosecute and spread the science after his death. They were coming shortly to England together, when, one day, Dr. S. said he himself was going alone to England; and he actually left Gall in a week, it turning out that he had been learning English with this view in Gall's house, without Gall's knowledge, for six months. Gall, therefore, affixed Dr. S.'s name no longer with his own in the title-page: but the work went on, as when Dr. S. was with Gall. The second,

Whoever acquires sufficient knowledge of the subject to make observations for himself will soon find the shape of the skull to

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third, and fourth volumes were completed, in the same style, with the name of Gall only; and what had been printed in the joint names of Gall and Dr. S. was undistinguishable from the rest, was evidently the production of the same genius, and remained the sole property of Gall, and the disappearance of Dr. S.'s name from it proved that it was none of his. In the remaining parts with only Gall's name, was done all that had been promised in the first volume which bore both names. Gall, in the rest of his work, always referred to the former parts, which bore Dr. S.'s name also, as solely his own. — "Tout ce que *j'ai* dit dans le premier volume," &c. "Dans le premier volume de cet ouvrage, *j'ai* exposé l'anatomie," &c. "Dans le second volume *j'ai* abordé le but principal de *mes* recherches." (4to. vol. ii. p. 251., iii. p. xv.) In his preface to the 8vo edition he says, "It is three years since the publication of *my* great work on the anatomy and physiology of the brain was finished (4 vols. fol. and 4 vols. 4to.), now to be had of the *author*, and at N. Maze's, bookseller, No. 4. Git-le-cœur Street. He then informs his readers, that, though *he* had thought it necessary to publish a work worthy of the object, he had been requested on all sides to publish an edition of it which might be within the means of every body. At p. 73. he refers to the first volume "de *mon* grand ouvrage," and so in numerous other parts (ii. 432., v. 502., vi. 165., iii. 70.). He then recapitulates all the anatomy of the large work, and all the physiology, as his own, without thinking of mentioning Dr. S.'s name any more than Dr. Magendie's. (l. c. t. vi. p. 497. sqq.) On this Dr. S. never ventured to remark. Gall thenceforth generally used the words *I* and *my*, except when Dr. S. had witnessed any thing with him. For Dr. S., being engaged to travel with him, after he had brought his science to such fulness that he determined to lecture upon it in various countries, necessarily, he says, made "une grande partie de mes observations en commun avec moi." (8vo. t. i. p. vii.) Even in the preface to the first volume, he spoke of all the discoveries, anatomical and physiological, as having long been made; but that, rather than yield to a desire of fame, he had preferred allowing others to publish them, and presenting a work to the public which should be supported by "more abundant observations and more positive results;" — a remark agreeing with his assertion to me, that, after he had engaged Dr. S., he only collected more facts in illustration of his discoveries and made additions which were mere shades of knowledge. Dr. Georget, in his book referred to p. 371. *suprà*, published in Paris soon after the appearance of the great work, speaks of it as Gall's, and addresses his remarks to Gall. (Gall, 8vo. t. v. p. 448. sqq.) I formerly exhibited Dr. S.'s injustice to Gall in regard to anatomy; he is equally unjust in regard to physiology. While he is obliged to detail Gall's discoveries and acknowledge him the founder, he inconsistently says, "Gall has the great merit of having *begun our* phrenological discoveries." "He had pointed out *many* relations which exist between various talents and characters of man and instincts of animals, and certain cerebral parts, before I was so happy as to become acquainted with him." (*Notes* to the article in the *Foreign Quar-*

be as various as character and countenance, and will have hourly amusement both in remarking the relation between intellectual

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terly, p. 60.) Gall had only begun! he had begun *our* researches! he had pointed out many relations! Here is enough, again, to stamp Dr. S.'s character for shortsightedness and effrontery, through his insane ambition. "*Plusieurs relations!* vingt-sept facultés!" says Dr. Vimont: "Ce mot *quelques* ne me paroit pas seulement une injustice; c'est une maladresse; car il resulte des faits avancés dans le corps de l'ouvrage de Spurzheim que Gall avoit déjà découvert, par la voie expérimentale, le nombre de facultés que je viens de citer. La prétention donc de Spurzheim au titre de fondateur nous paroit tout-à-fait injuste." (l. c. vol. ii. p. 53.)

Although Madame Gall, being well acquainted with all the affair, freely, like a good wife, bestowed upon Dr. S. the titles of *jésuite, ingrat, perfide, voleur*, Gall was always dignified and calm, and on these occasions usually said to her, "*laissons cela.*" He considered himself basely treated, but trusted to posterity for justice. He always contented himself with saying, if others mentioned S.'s conduct, "C'est un mauvais homme!" even on his death-bed, when, after much difficulty, he was prevailed upon to consent to see Dr. S., though his wife prevented the interview. When he mentioned, in the middle of the second volume, that he united Dr. S.'s name with his own no longer, he entered into no particulars. He afterwards yielded to the wish of his friends to take notice of Dr. S.'s publishing, like so many other of his auditors, a very incomplete account of his doctrines (un traité très-incomplet de ma doctrine), and "pretending in many places to have introduced views much more philosophical than those of the original author, who, according to the expressions of Dr. S.'s friends in the journals, had left his child in its cradle." (4to. vol. iii. p. xvi.) He then accused Dr. S. of having copied 246 pages of his quarto work into his own 8vo of 361 pages. "He will affirm," says Gall, "that he had a right to do so, because he worked with me at the first volume and the sections on innate dispositions. But he knows that his occupation was to furnish merely the literary notices. He should, at least, have mentioned the sources of his riches. He had not the same right over *my* sections on the organ of the soul and the plurality of organs. Others have already accused him of plagiarism: it is, at any rate, very ingenious to make books with scissars." Yet such was Gall's philosophy that he told me that, although Dr. S.'s conduct had been such as to determine him never to see Dr. S. again, he was far more vexed at the speculative turn which Dr. S. gave to phrenology,—more vexed that, while he himself had adhered closely to observation, Dr. S. had introduced conjecture and inference from too few observations. Gall lamented to me this turn in the Edinburgh phrenologists; and so, strange to say, did Dr. S. Having once expressed his opinion of Dr. S.'s conduct, he was too dignified ever to revert to the subject in the rest of the work, and merely refuted him here and there on points in which Dr. S. had broached new and erroneous opinions. Dr. S. in his *Essai Philosophique*, in 1820, attempted a defence, but with so much misstatement, sophistry, and rudeness, and withal weakness, that Gall, though he

and moral character, sexual, national, and individual, and cranial form and size, and in tracing the resemblance of children to their

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published his six 8vo volumes, one by one, afterwards, never condescended to notice it, satisfied that his own writings rendered any specific refutation superfluous, and always convinced that such matters right themselves with posterity. He spoke of all his own discoveries, as I mentioned in the last page, without feeling it necessary to allude to Dr. Spurzheim's absurd claims. I always felt certain that Dr. S. was an unhappy man, though I could not tell why before I studied the works of Gall and had the unspeakable happiness and advantage of knowing him personally. Every sentence in Gall's works is his own; and every thing in Dr. S.'s writings, which is also in Gall's, belongs to Gall.

I mention all this from my veneration for Dr. Gall, and my anxiety to see justice done him. Very few in this country have studied Gall. I am not acquainted with six persons whose native tongue is English, even among writers and lecturers on phrenology, who have not learned phrenology second-hand from Dr. S., or third-hand from Mr. Combe's writings, since these are in English, and comparatively short, while Gall's are in French, and of great extent. That the injustice done to Gall is such as to demand the pains I have taken, is proved by the custom among phrenological writers in the English language of speaking of the *system of Gall and Spurzheim,* of the *founders* of phrenology (for instance, *Ed. Phr. Journ.* No. iv. p. 628., No. v. p. 98. 110., No. vi. p. 186.) and the habit of such writers of quoting from Dr. S.'s works, passages which were written by Gall and are taken from his works. (Mr. Combe, *Phrenology*, p. 100., also p. 3. 5. and 44.) Nay, many of Dr. S.'s friends used always to declare that Gall had not given the philosophy of phrenology, but merely collected facts. At a public dinner given to Dr. S., Mr. Combe unintentionally disparaged Gall by declaring that Dr. Spurzheim had infused philosophy and system into the facts brought to light by observation. * Oh! shade of Gall! Had Mr. Combe studied every line of Gall's two works again and again, and hung over them at midnight as I have, and conversed with Gall as I did again and again, I am sure he is so conscientious that he would not have written thus! — that all the

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* *Edinburgh Phrenological Journal,* vol. v. He then called Dr. Spurzheim Gall's "rival in genius." In his *Phrenology* (p. 53.), he says that Dr. S. formed "the truths brought to light by their joint observations, into a beautiful and interesting system of mental philosophy." Gall's works are said, in the *Journal,* No. vi. p. 188., to be "more like a collection of *unconnected* facts;" while Dr. S. has given them "more the character of a science" "by a *more* systematic and philosophic arrangement." Mr. Carmichael's feelings towards his friend Dr. Spurzheim do him credit, but have rendered him, like Dr. S.'s other friend,—Mr. Chenevix, guilty of great misstatement and great injustice towards Gall, in his *Memoir of the Life and Philosophy of Spurzheim.* Dublin, 1833. See p. 4. sqq. 9. sq. 51. He says that Gall examined the brain "according to the old school and with mere mechanical views" till Dr. S. joined him!!

parents in the latter respect, as well as in talent and disposition; and he will not merely find incessant amusement, but feel himself

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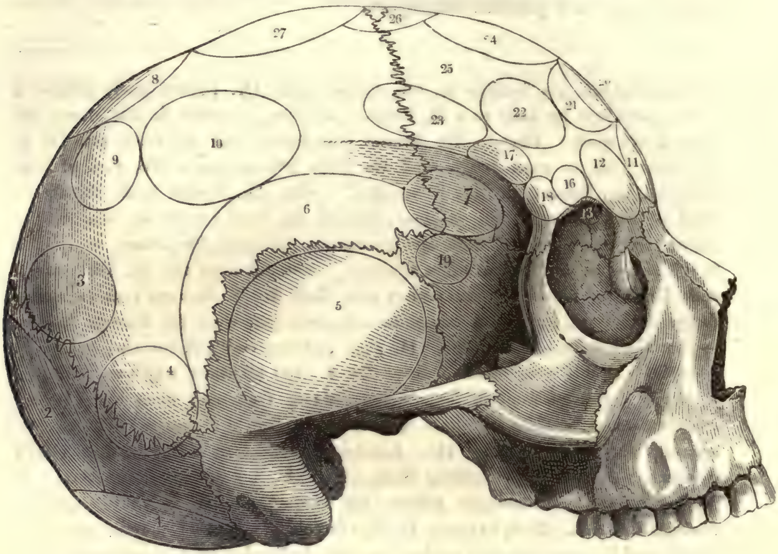
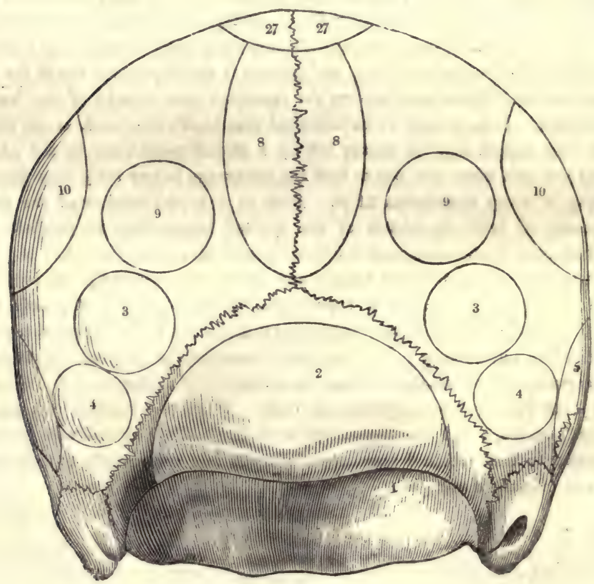
philosophy was Dr. Spurzheim's! In one part (*Phrenology*, p. 666.) he says that Dr. Spurzheim "is second in fortune rather than in merit to Dr. Gall!" "that we owe much of its excellence and interest to this gifted individual; he has enriched it with the most valuable anatomical discoveries; ascertained the functions of several highly important organs; shed over it the lights of a refined and analytic philosophy, and pointed out the most important field of its application:" "with profound gratitude and respect, therefore, I acknowledge myself indebted," not to Gall, but "to Dr. Spurzheim, for the greatest gift which it was possible for one individual to confer on another, — a knowledge of the true philosophy of man." In the *Ed. Phr. Journ.* No. vi. p. 186., the editors "are almost inclined to doubt whether they are right in assigning Dr. S. a place second to any." (l.c.p. 666.) M. Chenevix, in the *Foreign Quarterly* (p. 9.), among other incorrect statements, says that the old method of dissecting the brain appearing faulty, "Drs. Gall and Spurzheim were induced to invent some other mode." In America, where phrenology has been hitherto learned solely from Dr. S.'s book, and from himself personally, they are still more extravagant. "The labours of Dr. Spurzheim as an anatomist have produced a reform in the study of the nervous system which will for ever sustain him in the first rank of his profession. To be convinced of this, we have only to examine the state of knowledge in relation to the anatomy, physiology, and pathology of the brain and spinal marrow, before he devoted himself to the investigation of those most important branches of science." (Gall had therefore done nothing!) "That Spurzheim was superior to Gall as an anatomist, we believe all admit!" They then quote an assertion of Dr. S., that Gall once said to him, in 1805, "let us prosecute *our original plan* honestly; you, Spurzheim, as an anatomist, and I as a physiologist." If there was any truth in this, it could only have amounted to some kind encouragement of Gall to the young man; for Gall had then made all his important discoveries, and Dr. S. had only just finished his studies, just begun to learn to dissect the brain, and been engaged by Gall as his assistant. Hear the same writer again. "To express a preference is not to decide the question; and when we evince our partiality for Spurzheim as a philosopher, we merely give an individual opinion. His views, in our estimation, are more philosophic than those of Gall; more consistent, and more practical. Spurzheim carefully studied all the parts of the science with reference to each other, and aimed at a perfect whole. Gall did not do so much." (*Phr. in connection with the Study of Physiognomy, to which is prefixed a Biography of the Author*, by Nahum Capen. 1833. Nay, Dr. S.'s English friends at one time treated Gall's name with contempt, to elevate Dr. S. When Dr. S. lectured here, I heard his friends declare that his doctrines were worth their weight in gold — that *he* was the philosopher: whereas when I went to Paris, and conversed with Gall, I heard from his lips all the philosophy for which Dr. S. had gained credit in England; — I immediately saw the difference between the great original and the pupil. Those who are well acquainted with Gall's writings, and knew both him and Dr. S. in

possessed of a power in his intercourse with men and books relating to the human character, to which those unacquainted with phrenology are perfect strangers.

Paris, enter into my feelings on this subject; and Dr. Fossati lately printed a letter published by Gall to a M. Retzius, in 1798, in which he laid down the plan of his work. Because Dr. Fossati complained that too many put Dr. S. on a par with, or even above, Gall, the *Edin. Phren. Journ.* No. xlvi. p. 506. reproved Dr. Fossati for this "twaddle." But Dr. Fossati spoke the truth. Gall is, indeed, called the original; but, in the next breath, we hear of the *founders*, or the *system of Gall and Spurzheim*. See *Ed. Phr. Journ.* as quoted in the last page, and various other writings. Yet, although the *Ed. Phr. Journ.* calls Dr. S. the founder of phrenology with Gall, Dr. S. does not venture such a dangerous length, but on all occasions acknowledges, what all Europe knows, — that Gall is the sole founder. He only reduces Gall's discoveries as low as possible. It tells very much against Dr. S., that all those who were intimate with him have been more or less unjust towards Gall, and some have spoken contemptuously of Gall, in regard to both his intellect and moral feelings, contrasting him with Dr. S. One London phrenologist declared that Gall's forehead was only for collecting facts, while Dr. S.'s was for philosophy. A great Edinburgh phrenologist referred me to the inferiority of Gall's organ of conscientiousness. Now, in truth, Dr. S.'s forehead is far less full and square than Gall's, and his whole coronal surface together, indicating the high moral feelings, equally inferior to that of Gall. The intellectual and high moral part of Gall's head are magnificent, and those of Dr. S. will bear no comparison with them. His firmness, self-esteem, and courage also are so large that we see at once how he was enabled to rear phrenology, and present it steadily to the world for so many years, standing alone and braving the contempt and attacks of the learned and unlearned. It is greatly to be lamented that Gall's 8vo work is not translated; and I am certain that the legacy left by a Scotch gentleman to aid phrenology could not have been laid out to half the advantage in any other way than in publishing a cheap translation of it. Pure as were the motives of the gentlemen intrusted to fulfil the wishes of the spirited bequeather, in publishing works of their own, I am convinced that they would have done far better in publishing the writings of the founder before any thing else, — writings so eloquent and convincing, and so divested of speculation, so overwhelming in proofs, that their translation would have formed the surest foundations for a universal conviction of the truth of phrenology. The injustice I complain of in phrenologists arises, I am certain, solely from their not having studied Gall as they have Dr. S., and from many not having read a syllable of Gall. When my reading was confined to Dr. S.'s books, and I was acquainted with him only, I committed the very same injustice to Gall which I now most earnestly and respectfully entreat phrenologists to commit no longer.

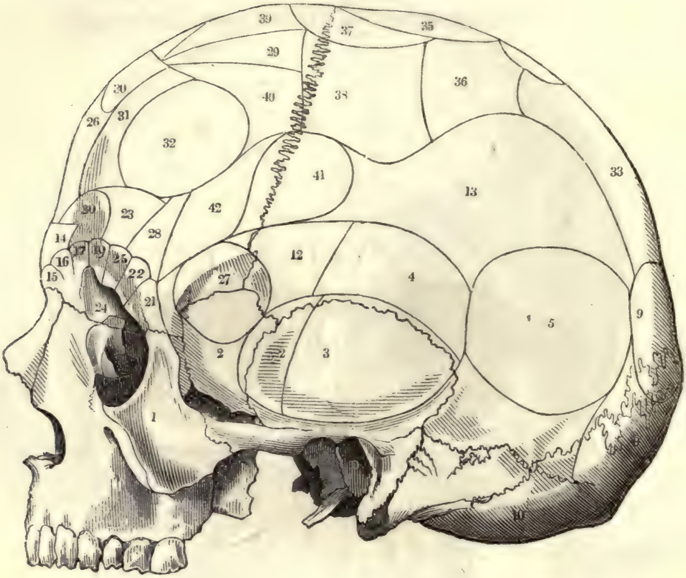
I shall here present some views of the organs according to Gall. The references will be found *suprà*, page 349. sq.





The following are from Dr. Vimont, and show all the organs admitted by both Dr. Spurzheim and himself.

1. Conservation.
2. Alimentation.
3. Destruction.
4. Cunning.
5. Courage.
6. Choice of places.
7. Concentration.
8. Attachment for life, or marriage.
9. Attachment.
10. Reproduction.
11. Attachment to the produce of conception.
12. Property.
13. Circumspection.
14. Perception of substance or objects.
15. Configuration.
16. Size.
17. Distance.
18. Geometrical sense.
19. Resistance.
20. Localities.
21. Numbers.
22. Order.
23. Time.
24. Language.
25. Colouring.
26. Eventuality.
27. Talent of construction.
28. Musical talent.
29. Talent of imitation.
30. Comparison.
31. Causality.
32. Discrimination.
33. Vanity.
34. Self-esteem.
35. Firmness, perseverance.
36. Conscience.
37. Veneration.
38. Hope.
39. Benevolence.
40. Sentiment of the marvellous.
41. Poetical sentiment.
42. Sentiment of the beautiful in arts.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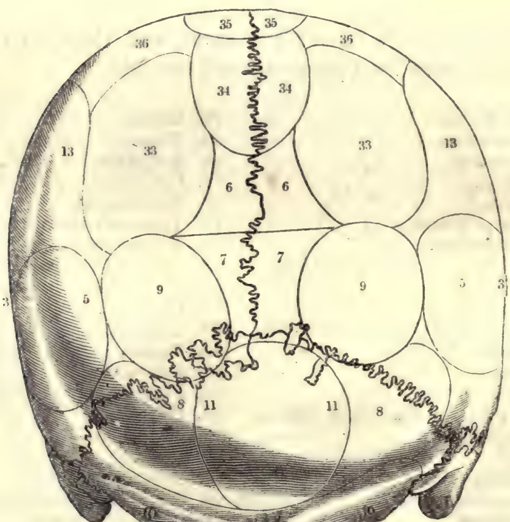
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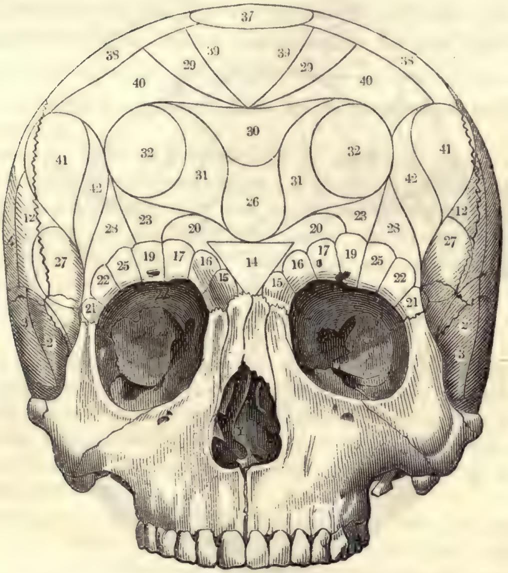
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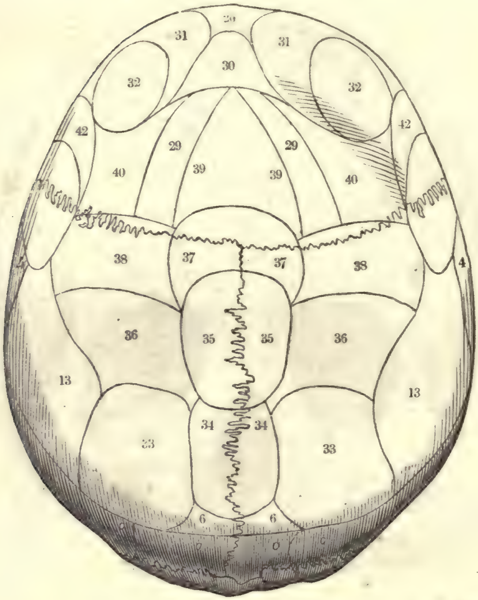
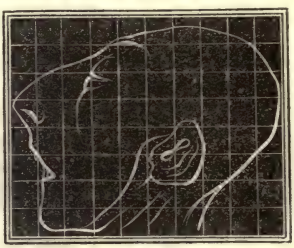
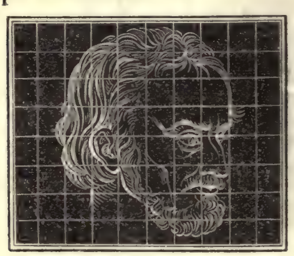
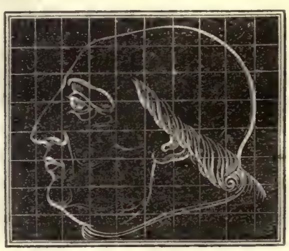


As an intellectual contrast, I present the head of Gall and of a Dutch adult idiot, whose skull is delineated by him, and is in the National Museum at Amsterdam, where I have seen it.



As a moral contrast, I present the head of Melancthon and of Pope Alexander VI.





Should any one doubt his acquaintance with the real talents and character of those friends whose heads he can select for ob-

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I must here subjoin some remarks from Gall on the reception which has been given to phrenology.

"The followers of the different schools of philosophy among the Greeks, accused each other of impiety and perjury. The people, in their turn, detested the philosophers, and accused those who investigated principles, with presumptuously encroaching upon the rights of the deity. The novelty of the opinions of Pythagoras caused his banishment from Athens; those of Anaxagoras threw him into prison; the Abderites treated Democritus as a madman, because he dissected dead bodies to discover the cause of insanity; and Socrates, for demonstrating the unity of God, was condemned to drink hemlock.

"The same scandal had been renewed at all times and in all nations. Many of those who distinguished themselves in the fourteenth century by their knowledge of natural things, were put to death as magicians. Galileo, for proving the earth's motion, was imprisoned at the age of seventy. Those who first maintained the influence of climate upon the intellectual character of nations were suspected of materialism.

"Universally, nature treats new truths and their discoverers, in a singular, but uniform manner. With what indignation and animosity have not the greatest benefits been rejected? For instance, potatoes, Peruvian bark, vaccination, &c. As soon as Varolius made his anatomical discoveries, he was decried by Sylvius as the most infamous and ignorant madman. *Vesanum, litterarum imperitissimum, arrogantissimum, calumniatorem maledicentissimum, rerum omnium ignarissimum, transfugam, impium, ingratum, monstrum ignorantiæ, impietatis exemplar perniciosissimum, quod pestilentiali halitu Europam venenat,* &c. Varolius was reproached with dazzling his auditor by a seductive eloquence, and artificially effecting the prolongation of the optic nerves as far as the thalami. Harvey, for maintaining the circulation of the blood, was treated as a visionary; and depravity went so far as to attempt his ruin with James and Charles the First. When it was no longer possible to shorten the optic nerve, or arrest the course of the blood in its vessels, the honour of these discoveries was all at once given to Hippocrates. The physical truths announced by Linnæus, Buffon, the pious philosopher Bonnet, by George Le Roy, were represented as impieties likely to ruin religion and morality. Even the virtuous and generous Lavater was treated as a fatalist and materialist. Every where do fatalism and materialism, placed before the sanctuary of truth, make the world retire. Every where do those, upon whose judgment the public relies, not merely ascribe to the author of a discovery the absurdities of their own prejudices, but even renounce established truths if contrary to their purposes, and revive ancient errors, if calculated to ruin the man who is in their way.

"This is a faithful picture of what has happened to me. I have, therefore, some reason to be proud of having experienced the same lot as men to whom the world is indebted for so great a mass of knowledge. It seems that nature has subjected all truths to persecution, in order to establish them the more firmly; for he who can snatch one from her, always presents a front of brass to the darts hurled

servation, he has only to study the heads of some celebrated men now living, or the authentic casts of the departed, of whose talents

against him, and has always force enough to defend and establish it. History shows us that all the efforts and sophisms which are directed against a truth once drawn from darkness, fall like dust blown by the winds against a rock.

"The instance of Aristotle and Descartes should be particularly quoted, when we wish to display the influence of prejudice upon the good or bad fortune of new doctrines. The opponents of Aristotle burnt his books; afterwards, the books of Ramus, who had written against Aristotle, were burnt, and the opponents of the philosopher of Stagira declared heretics; and it was even forbidden by law to dispute his doctrines, under pain of being sent to the galleys. Now there is no longer any discussion about the philosophy of Aristotle. Descartes was persecuted because he taught the innateness of ideas, and the University of Paris burnt his books. He had written the most sublime thoughts upon the existence of God; Voët, his enemy, accused him of atheism. Afterwards, this same university declares itself in favour of innate ideas; and when Locke and Condillac attacked innate ideas, the cry of materialism and fatalism resounded on all sides.

"Thus, the same opinions have at one time been regarded as dangerous because they were new, and at another as useful because they were ancient. We must, therefore, pity mankind, and conclude that the opinions of contemporaries as to the truth or error, and dangerous or innocent tendencies, of a doctrine, are very suspicious, and that the author of a discovery should be anxious only to ascertain whether he has really discovered a truth or not. A truth once discovered, will make its way, and not fail to produce good effects. 'Reason,' says Ancillon, after Bonnet, 'knows no useless nor dangerous truths. What is, is.' This is indisputable, and is the only answer to be made to those who, putting all things in subordination to men's wants, ask, What is the use of that? and to those who, always yielding to fear, ask, What may that lead to? Jesus, the son of Sirach, had already said, 'we ought not to ask what is the use of that: for the use will have its reward in time.'" *

When delivering the Lumleyan lectures, and asserting the importance of percussion and auscultation, for the first time, before the College of Physicians, in 1829, I reminded the College, "that the greatest discoveries had generally been at first ridiculed, and their authors, no less than all the truest benefactors of the human race, despised and rejected of men.

—— 'Romulus, et Liber Pater, et cum Castore Pollux;
Dum terras hominumque colunt genus, aspera bella
Componunt, agros assignant, oppida condunt,
Ploravêre suis non respondere favorem,
Speratum meritis.'" Hor. *Ep.* 1. lib. ii.

* l. c. 8vo. t. i. p. 221. sqq., 4to. t. iv. p. 75. sqq., where alone the sentence "a truth once discovered," is found; but where the third and fourth paragraphs are not.

or disposition no one can have the slightest doubt, and he will find the coincidence, within the limitations which I mentioned, astonishing and invariable.

I then mentioned the fate of Harvey (v. *suprà*, p. 194. sq.)*, and the original rejection of the discovery of the lacteals (v. *suprà*, p. 140. sqq.), and continued: —

"Let us remember that Sydenham, whose memory *we* also honour, was, by many of his contemporaries, whose names, whatever bustle they made during their existence, have never once been mentioned since their death, *called* a quack and a murderer.†

"Let us remember, that, if the illustrious father of modern philosophy was not vilified and imprisoned, like Galileo, for announcing truth, he was represented by Cecil to Elizabeth, when she thought of making him her solicitor-general, 'as a man of mere speculation, — as one wholly given up to philosophical inquiries, *new indeed and amusing*, but *fanciful and unsound*, and therefore more likely to distract her affairs, than to serve her carefully and with proper judgment.'

"In ancient times, Horace saw his odes despised because they were *new*. The public, he said,

—— 'Nisi quæ terris semota, suisque
Temporibus defuncta videt, fastidit et odit;
Est vetus atque probus centum qui perficit annos.'

But, like the illustrious Gall, Laennec is no more.

'Extinctus amabitur idem.'

"In the words of Professor Playfair, notwithstanding the splendour of Newton's discoveries; the beauty, the simplicity, the grandeur of the system they unfolded, and the demonstrative evidence by which that system was supported;" "the Cartesian system of vortices kept its ground for *more than thirty years* after the publication of these discoveries," "and actually the Newtonian philosophy first entered the University of *Cambridge* under the protection of the Cartesian," by a stratagem of Dr. Samuel Clark, who quietly explained the views of Newton, without any appearance of argument or controversy, in the form of notes to a new translation which he published of the French Cartesian work, long established as the text-book by the tutors of the University.

"Dr. Chalmers, speaking of the first reception of the Newtonian philosophy, says, 'Authority scowled upon it, and taste was disgusted by it, and fashion was

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* I might have added the words of the *Edinburgh Review*, No. xciv.: "The discoverer of the circulation of the blood suffers no diminution of his reputation in *our* day, from the *incredulity* with which *his doctrine* was received by some, the *effrontery* with which it was *claimed* by others, or the knavery with which it was ascribed to former physiologists."

† Here I might have added that, though Sydenham resided in Pall Mall, he was never employed by the Court; yet the names of the Court physicians of his day are now no more known than the names of the Court footmen.

If these are facts, all objections on the score of fatalism and materialism are unworthy of attention. Because no rational

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ashamed of it.'" (My Lumleyan *Lectures on the Diseases of the Heart,* referred to *suprà,* p. 174.)

Father Pardies wrote against the experiments and what he was pleased to call the *hypotheses* of Newton,—the very words of uninformed antiphrenologists. Such great astronomers and mathematicians as Cassini and Maraldi were calculating the paths of comets on the most imaginary and unfounded hypotheses, long after Halley had constructed tables on the principles of Newton, in which the motions of all comets that ever had appeared or could appear might be easily deduced; and Voltaire remarks that, though Newton lived nearly forty years after the publication of his *Principia,* he had not twenty followers out of England at the time of his death. Some great philosophers died in perfect ignorance of them.

The introduction of Greek was originally opposed with violence at Oxford, though now it is taught there as one of the most important things that a well educated man can know.

The music of Gall's countryman, Handel, though it has enraptured the English for a century, is now only beginning to be appreciated in Germany.

Even I have lived long enough to see things at once rejected with scorn, which are now all but universally adopted. When Laennec first published his great work, I procured a stethoscope and investigated his statements. Although the facts of percussion, as detailed by Avenbrugger above half a century ago, must of physical necessity exist, I had always been taught, by the first teacher of medicine in London, at Guy's Hospital, Dr. James Curry, that they were fallacies, and they were dismissed in three minutes as unworthy of the slightest attention. Education, therefore, tended to make me sceptical. But I soon found that Avenbrugger had been disgracefully neglected in this country; and that Laennec, like Avenbrugger, had opened to us a new and extensive scene in disease, to which, though it had always existed, we were blind—that we had eyes and saw not—or really, to drop metaphor, that we had ears and heard not. For a length of time I found some at St. Thomas's treat percussion and auscultation with ridicule; some with absolute indignation; and others, for years, treated it with silent contempt; who all, I am happy to say, now practise both. I was therefore in the habit of studying them in the wards alone, and at hours when I expected to be unobserved. When I at length advocated and taught them in the school, one of my colleagues, I heard, pronounced it nonsense or worse in his lecture; and at the College of Physicians I heard a senior fellow, in a Croonian lecture, denounce the folly of carrying a piece of wood (some called the stethoscope *inutile lignum*) into sick chambers and making observations, to the destruction of all philosophical and dignified views, such as become men whose minds have been enlarged by the education which Oxford and Cambridge afford. When another fellow of the College was asked his opinion of auscultation in the wards of his hospital, he at once, as I was informed by the gentleman who asked the question, condemned it as nonsense; and when told "that Elliotson assured his friends that he had a high opinion of it and made his diagnosis of affections of the chest with infinitely more accuracy by its means," he replied,—

or religious person believes that one truth can contradict another; or that a truth can lead to any thing but good. But,

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" Oh! it 's just the thing for Elliotson to rave about!" Yet good sense and truth have prevailed. This physician is now addressed as one who had the candour to examine auscultation at an early period, when others despised it, and who materially assisted to spread its adoption. Even Dr. Spurzheim was as unphilosophical on this point, as others were in regard to phrenology. On seeing a stethoscope one day upon my table, he said — " Ah! do you use that hocus pocus?" And on my replying that it was highly important to employ the ear, he added, " You learn nothing by it; and if you do, you cannot treat diseases the better." Both which remarks were incorrect, and showed an unhappy state of mind. An old physician, on seeing me use the stethoscope, began our consultation by informing the practitioner, whom he had never seen before, and myself, that he " never made use of these French fooleries." Yet ignorance of percussion and auscultation is now considered a sufficient proof that a man knows but half his profession, and Laennec's name has become imperishable; and I am happy in looking back upon the assistance I rendered to the establishment of auscultation and percussion in this country by making the numerous physicians' pupils of St. Thomas's Hospital ear-witnesses of facts which others in vain attempted to bring into contempt.

For years after I published my work on Prussic Acid, in 1820, referred to *suprà*, p. 223., very few persons would employ it; and I was not only ill spoken of for recommending what was useless, but till very lately condemned for using dangerous poisons. Not three years ago, a practitioner whom I had never seen or even heard of, urged this in an argument with a nobleman to prevent me from being consulted in the case of his lady. While the last edition of the Pharmacopœia was preparing, in 1824, the committee drew up a Latin formula for its preparation: but when they presented their sketch of the new list to the College, they begged to withdraw the formula for prussic acid, because they had received so many letters from fellows against its utility and safety. It was consequently not admitted; and it was said in a medical journal, ten years ago, to be no longer employed by the profession. Yet it is now employed universally and daily by good practitioners of all ranks, for some pectoral complaints, for which it had been recommended on the Continent, but chiefly for stomach affections, in which I had discovered its great utility; and all my statements of its properties are established. And, although for my knowledge of its properties in regard to the stomach I was indebted to no one, I was compelled to show a second time how accident first made me acquainted with its power over the stomach, and how I was led on step by step to investigate and discover its great virtues in affections of this organ. (See the *Lancet*, Feb. 24. 1827, p. 671. sqq.)

Three months after I had first published (in the *Transactions of the Med. and Chir. Society*, for 1823, vol. xii.) a full report upon Quinine (the first that appeared in this country), I heard, at a meeting of the College of Physicians, an hospital fellow on one side of me, ask another hospital fellow, who is now in high practice, what he thought of this Quinine. The reply across me was, " Nothing; the very

in reality, phrenology gives no *additional* support to such views. It leaves all questions of fatalism and materialism where it found

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name of it will not be known in a twelvemonth!" Yet Quinine is now as much used as rhubarb, though neither it nor Prussic Acid is in the Pharmacopœia; and all my statements are established.

In 1824, I published my discovery of the almost specific power of carbonate of iron in cases of general chorea before the adult period; and for pointing out (l. c. vol. xiii. 1827.) that Carbonate of Iron, when it failed in ordinary doses, might be given without the least unpleasant effect in doses ten times larger, I was considered little less than a fool, and acquired a permanent reputation for giving all medicines under all circumstances in enormous doses; though I am one of the most cautious practitioners, and always begin, in chronic cases, with small doses of medicine, increasing them by slow degrees according to the necessity; and never, from my earliest days of practice or teaching, have wished to give one grain or one drop more than proves requisite. At the same time, I certainly do not regard quantity as I proceed, but steadily augment my doses till the complaint begins to yield, or some effect of the medicine begins to appear. No practice is more irrational than to discontinue a medicine simply because it does nothing, or before you have step by step augmented the dose till some circumstance manifests that the medicine is not inactive. Difference of quantity and difference of continuance must be demanded in different cases. I did not feel myself justified in recommending large doses of iron as more efficient than small. But farther experience proved to me the superior power of large doses of carbonate of iron in obstinate cases; and in 1827 (l. c. vol. xiii.), I stated this, and have proved it to the crowds of students at the North London Hospital again and again. The possibility of giving the large doses of the medicine ordinarily is now no longer doubted. I next announced the power of large quantities of Carbonate of Iron over Tetanus (l. c. vol. xv. 1829.), and this has been confirmed. (*Lond. Med. Gazette*, Sept. 14. 1833.) A gentleman from the West Indies told me he had great success with it. But no one else gives it a trial, and old means which have failed again and again are absurdly repeated.

When I displayed the utility of sulphate of copper in chronic diarrhœa, in 1827 (l. c. vol. xiii.), some contended that the opium combined with it effected all the good, although I had so proceeded as to prove how much was owing to the salt. I now possess heaps of letters expressing the realisation of my statements from practitioners of various parts.

In 1830, I proved the occurrence of glanders in the human subject, notwithstanding its possibility was denied. (l. c. vol. xvi.) I was smiled at for my credulity. Yet extracts from my papers and copies of my engravings have now a place in Dr. Rayer's work upon the Diseases of the Skin, to which no other is comparable; and, in noticing some foreign cases just published, the editors of the *Brit. and For. Med. Review*, for July, say the occurrence is no longer a novelty. (p. 241.) After my first paper appeared, the lecturer on veterinary medicine in the University of London, to whom I had given a copy, did not condescend to notice it; and, making a passing obervation upon the belief of the occurrence of the disease in the human subject,

them. Every thing in nature is subjected to laws which must be obeyed. The nature of every thing is destined. A stone is des-

was perfectly silent in regard to my facts, and considered such an opinion as the result of inaccurate observation, referring to some one else, not to me. (*Lancet*, No. 436.) After my second paper was published, (l. c. vol. xviii. 1833.) in which I gave another case, he could no longer profess a doubt; but, in admitting the fact, now said that it had "long been suspected, or rather painfully known." (*Veterinarian*, March, 1833.)

For having discovered the extraordinary power of Creosote in arresting vomiting, unconnected with inflammatory or structural disease of the stomach, in an immense majority of cases (l. c. vol. xix. 1835.), I am now going through a course of sneers and attacks. Some who cannot have, and others who evidently have not, employed it according to my directions, nor to one twentieth of the extent, assert that they have not found it so useful as I have, and put it on a par with medicines as inferior to it as lettuce to morphine: and the reviewers, who are lauded as respectable above all others, untruly say that I call it never failing; whereas I pointed out two forms of vomiting in which it is useless and even injurious, and mention that where it seems proper it occasionally fails, and that it so disgusts some persons that the stomach will not bear it; and, though, after a laborious and rigid examination of its effects for a twelvemonth in a large practice, I have pointed out various diseases and forms of disease in which it is useful, I really have pronounced against it in a still greater number of diseases and opposed writers who eulogised it absurdly. I shall always congratulate myself upon my good fortune in discovering the extraordinary power of creosote over nausea and vomiting and to enable the stomach to bear medicines which disagree with it; and all I stated in regard to it is confirmed by still farther hourly experience up to this very day, and will stand firmly, notwithstanding the assertion of Drs. Forbes and Conolly, who untruly make me have "unlimited confidence" in creosote and call it "never failing," and who assert that "in other and equally judicious hands it has fallen very far short of the virtues ascribed to it" by me, "and that it more frequently fails" in cases in which I say I have found it successful. To crown all, they make a lecturer, who confirms a candid remark of mine, be confirmed by me. (July, p. 170. 200.) The testimony of hundreds of my pupils and patients is happily against them.*

* Except the narrative of a case of rupture of the stomach (l. c. vol. xiii.), and one of rupture of a pregnant Fallopian tube (l. c. vol. xiii.), my only other paper in the *Transactions* is on Fatty Discharges from the Alimentary Canal and Urinary Passage (vol. xvii. 1833.). In it I collected a great many instances, and deduced several general facts as to the disease. 1. That the fat might be discharged solid or liquid, or both. 2. That the disease might be temporary, or permanent, or even fatal. 3. That there might be organic, or merely functional disease. 4. That the organic disease might be in the intestines, liver, or pancreas. 5. That fatty discharge might take place from the alimentary and urinary organs at the same time. Yet this paper was called a mere collection of cases.

tined not to feel; a fish is destined to swim, and a vulture to be a bird of prey; man is destined to be —

What I experienced during many years for my humble and conscientious efforts to propagate the advancement of whatever, by zealous and dispassionate observation I knew, within my own experience, to be true and useful, distressed me greatly, till I rose in spite of it in my profession. I am aware of the injuries I still suffer from the bad feeling of those who are not so devoted to the profession as myself and yet envy me. But I now smile at it, and forgive all; and shall firmly persevere, never withholding my aid to useful truths nor shrinking from conduct which I consider my duty.—From this narration I trust that young men will never be deterred from an industrious and conscientious course, but be prepared to expect all that I have experienced, and remember the advice of the Sibyl to Eneas, "Tu ne cede malis, sed contra audentior ito." We thus find the fate of the little to be the same as of the great, if they humbly take these for their guide.

But the most notorious modern illustration of the aversion to improvement is the history of lighting with gas. When I was a student, I recollect often going from the Borough Hospitals in the evening to see Pall Mall, which only, of all the streets of London, was so lighted. For many years a person named Winser, and a company which he established, lighted that single street, I believe gratuitously. This was a bright spot in London, for comparative darkness prevailed in every other street. For many years, the general adoption of the plan was considered impracticable and therefore absurd. At length, another street was lighted — and another — and another — and now that the poor man is dead, all London is become Pall Mall, with one exception. Year after year have I amused myself with watching the progress of illumination, and comparing it with the history of the progress of great truths in physical, moral, and political science. Yet not even is it at this moment universally adopted, any more than many obvious truths. Darkness is still cherished in that very spot of London, where the greatest riches and the highest rank, both transmitted hereditarily in the longest succession, ought to have secured, with Oxford and Cambridge education and every advantage of mental cultivation, from generation to generation, the highest knowledge and discernment. No house in Grosvenor Square has any other than the greasy, dull oil lamps, notwithstanding all the streets opening into it and even the centre of the square which the parish lights, are brilliantly illuminated with gas. I have taken foreigners into Grosvenor Square to exhibit this *moral* phenomenon.

These are all remarkable facts in the history of human nature; and make me quite indifferent to the opinions of people, whether in my own profession or not, upon the subject of phrenology. Yet its progress has of late been most satisfactory. When I wrote advocating phrenology, in 1817 *, the year of my

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* *Annals of Medicine and Surgery*, vol. ii. March 1817. I believe I was the first reviewer who defended phrenology in Great Britain. I subsequently wrote a review of the *Ed. Phr. Trans.* and of the first Number of the *Ed. Phr. Journ.*

——— "Not prone
And brute as other creatures, but endued
With sanctity of reason, and to erect
His stature, and upright, with front serene,
Govern the rest, self-knowing." [u]

The very expression "human nature" implies certain innate faculties and dispositions, *generally;* the circumstance of *peculiar*

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appointment to St. Thomas's Hospital, I did not know six phrenologists in England; and, when I founded the Phrenological Society of London there was none in England or abroad. They now exist in many parts of Scotland, where the first Phrenological Society was established; in many parts of England, in Ireland, America, Denmark, and Paris, where, however, no one existed till Gall's career was finished, — 24 societies in all. In Paris the most distinguished in our profession are phrenologists. To the everlasting honour of Edinburgh, not only was the first Phrenological Society established there, but the first Phrenological Journal; and a treatise on the science by Mr. Combe has passed through three editions, and made its hundreds of converts: 14,000 copies of his phrenological works have been sold. (*Statistics of Phrenology*, by H. C. Watson. London, 1836.) On the stand made by Mr. Combe and his circle in Edinburgh, the seat of a hostile celebrated Review, of a University, and of great religious bigotry, too much praise on the score of intellect and moral principle cannot be bestowed. Thousands of well-informed persons in this country are now phrenologists, — a very large number in my own profession. Though the Pope put Gall's works into the Index Expurgatorius, phrenological treatises have lately been permitted in the states of his Holiness, as well as by Austria in Milan and Pavia. Phrenological language is of daily use with our best writers and teachers; though they too often fear to declare their conviction. I have never known an individual write or speak against phrenology,

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in Dr. Johnson's *Med. Chr. Review;* and have read in the London Phrenological Society a paper on Imitation, reported in the *Lancet*, 1827, No. 190. — on an Idiot, l. c. 1826, No. 169.—on the Head of the Incendiary Smithers, l. c. 1832, No. 486.—ditto Thurtel, — ditto Pallet, *Ed. Phr. Journ.* vol. i.— an Answer to Mr. Jerdan and Dr. Ryan, *Lancet*, No. 430.—to Dr. Kidd, l. c. 1834, No. 547. — to the Rev. Mr. Taylor, l. c. 1834, No. 548. — to Mr. Godwin, l. c. 1834, No. 432. — ditto to Dr. Pritchard, ditto to Dr. Burrows, but not reported, — ditto to Dr. Bostock, — ditto to Dr. Magendie, *Ed. Phr. Journ.* vol. v. In the *Lancet* for 1829, No. 304. and 1831, No. 400. will be found reported some curious pathological illustrations of Phrenology from my patients in St. Thomas's Hospital. In the *Ed. Phr. Journ.* vol. iv. also will be found a phrenological experiment, and in the *Lancet*, No. 642. another, both communicated by me previously to the London Phrenological Society.

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[u] *Parad. Lost*, vii.

degrees of disposition and talents being hereditary, and of each age having its distinctive character, are quite as favourable as

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without betraying a total misconception of it, or an ignorance of the facts of which the spoke. Some opposers are both ignorant and malicious.

Let us all, therefore, follow Gall's advice; and when, by careful investigation, we have satisfied ourselves of a truth, let us not be angry, but let us, remembering the words of Locke, — that few people have any solid reasons for the "doctrines they keep such a stir about" (*Hum. Underst.* iv. 21.), pity mankind and totally disregard the opinions of those who have not bestowed the same attention as ourselves or yield to malevolent passions, be they little, like the swarm, or men of real distinction.

Till Gall established himself in Paris and rose into a very fine and high practice (he was physician to many ambassadors), he kept himself very poor from spending upon his phrenological pursuits all he gained, after absolutely necessary expenses. And although he lived then in the most private manner, with the comforts indeed of a handsome lodging, a carriage, and a garden with a small house in the suburbs, he had saved so little, that, had his illness been protracted, his friends in a few months must have supported him. In his combination of intellect and moral sentiments, I doubt if any other human being surpassed him; and the frontal and sincipital regions of his head were magnificent. His cerebellum was very large, and he was twice married; and although, after separating from his first wife he had a mistress, I believe he was a model of fidelity, and married again immediately that his first wife died. His noble independence of mind cannot be better shown than in his account of self-esteem in which he evidently pourtrays himself, — a passage which I have ever in my thoughts. "There is a certain number of men endowed with such strength of mind and nobleness of soul, thoroughly sensible of their own worth, and so passionately fond of independence, that they resist every external influence calculated to subject them. They endeavour, as much as possible, to establish themselves in countries where there is the most liberty; they follow a pursuit which renders them independent, which exempts them from the favours and the caprices of the great. Dominion over their inferiors, which would lead on to slavery under an absolute master, to them would be insupportable. Honours and distinctions intended for merit, when lavished on men of no pretensions, are in their eyes only degradations. If they prosper, it is through their own exertions. Like the oak, they sustain themselves; and, for whatever they are, they consent to be indebted to no one. This is a pride which has not degenerated into haughtiness; which is often the companion of great virtues, is the enemy of all baseness, and the support of courage in adversity." (l. c. 4to. vol. iii. p. 299., 8vo. t. iv. p. 254.) "I am the most modest, the most humble of men, when I behold around me the immensity of things which I am condemned not to understand, and which, nevertheless, are connected with the objects of a medical observer and practitioner. But when the discovery of the structure and functions of the brain is spoken of, I believe myself, with imperturbable confidence, to be above all my predecessors, above all my cotemporaries. Yes; I am the first who has established the physiological principles on which the structure and

phrenology to the belief of *fatalism.* But each has his own precise talents and disposition by nature; on some circumstances or other

functions of the brain must be studied; I am the first who has broken down the barrier opposed by superstition and ignorance, for thousands of years, to the progress of the physiology of the nervous system; the first who conceived the idea of distinguishing the general attributes from the true qualities and fundamental faculties; the first who determined the instincts, the inclinations, the sentiments, and the talents which are connected with certain cerebral parts. I am the first who had the courage, the patience, and the perseverance to examine and fix the relations which exist between the energy of the moral qualities and of the intellectual faculties, and the various development of the parts of the brain. I am the first who has extended these researches to the whole brute kingdom, who has studied thousands of animals, as to their most striking instincts, inclinations, and faculties, and the configuration of their brain, both in individuals and species. I am the first who discovered and pointed out the means of discovering the seat of each instinct, sentiment, and intellectual faculty. I am the first who discovered these seats, and demonstrated them by numerous physiological and pathological facts, and by an infinity of researches into the comparative anatomy and physiology of all species of animals."

"Yes; once more, I am the first and the only one to whom the physiology of the brain owes its existence; I have discovered it without the assistance of any man. This the history of each of my discoveries proves. It is the same with the physiology of the brain as with its structure. To pick out what might by chance be found dispersed in authors, would have required more cleverness than to detect the mysteries of nature by observation. I began, continued, and completed all my discoveries, without any previous learning; and if, at a later period, I compiled quotations, it was rather to mark the point of my departure, than to strengthen my ideas by those of my predecessors and cotemporaries." (l. c. 8vo. t. v. p. 519. sq. 522. sq.)

In his preface to the third quarto volume, *published in* 1818, and the sixth octavo, *published in* 1825, he says, "The foundation of this doctrine being laid, it must be as immovable as the materials, — the facts, of which it is constructed. But I am far from believing the edifice complete: neither the life nor the fortune of one man would be sufficient for this vast project. *Up to this present moment I have been left to my own resources.* An immense concourse of the most favourable circumstances would be required to raise this study to the height which it is capable of attaining. There would be required a complete collection of the crania of brutes, not only of different species, but also of individuals in which qualities or faculties strongly pronounced had been observed. There would be required a complete collection of the brains of brutes, modelled in wax after nature, to multiply the means of comparison. There would be required a number of crania, or at least of casts, of men and women distinguished by some quality or faculty: finally there would be required a more extensive knowledge of natural history than we have at present, with respect to instances of industrious aptitudes, qualities, and faculties; in a word, with respect to the internal economy of the brute creation."

they must depend; and, if these are discovered, the case does but remain the same as before.[o] Yet, whatever may be our innate

Dr. Vimont of Caen has carried on the researches into the phrenology of brutes with extraordinary perseverance, and produced a most magnificent work. Attracted, in 1818, by the prize offered by the French Institute to the author of the best memoir upon the anatomy of the brain in the four classes of vertebrated animals, he began researches into the subject, without any reference to phrenology, for he had not read Gall, and had seen him spoken of in books and heard of him only as a charlatan: however, he thought it incumbent upon him to read Gall's work among others. "Hardly," says he, "had I begun to read it, when I found that I had to do with one of those extraordinary men whom dark envy endeavours to exclude from the rank to which their genius calls them, and against whom it employs the arms of the coward and the hypocrite. High cerebral capacity, profound penetration, good sense, varied information, were the qualities which struck me as distinguishing Gall. The indifference which I first felt for his writings, therefore, soon gave way to the most profound veneration." (*Introduction*, p. 14.)

In 1827, Dr. Vimont presented to the Institute a memoir containing a fragment of the researches on which he had then spent so many years, together with 2500 heads of brutes of various classes, orders, genera, and species. Among these, 1500 had belonged to brutes with whose habits he had been individually well acquainted before they died, or were killed: 400 wax representations of the brain, modelled after nature, and an atlas of more than 300 figures of the brain and cranium, executed with the strictest accuracy of dimensions, also accompanied the memoir. The work in which he now sets forth his observations has an atlas of 120 exquisite plates, containing above 600 figures. The accuracy of dimensions is said to surpass any thing before attempted in anatomy; and, if the immense mass of proofs of phrenology from the human head, and the facts pointed out by Gall, in brutes, were not sufficieht to convince the most prejudiced, the additional multitude amassed by Dr. Vimont will overwhelm them.

These are the great merits of the work: I would willingly pass over its faults; but antiphrenologists will point them out, and, therefore, it is as well at once to express my regret at the self-conceit which pervades it. The author has given what he terms English as well as French explanations of the plates, but, from not availing himself of the assistance of some one possessing a better knowledge of our language, his blunders are irresistibly ludicrous. He brings Gall's knowledge and labours as low as posible, in order to elevate his own, and commits great injustice. (Vol. i. p. 15. (Not aware that Gall had

[o] All know that sexual desires are so connected with the genital organs as generally to commence when these become mature, and be prevented by their removal during childhood; but the world does not, therefore, decline to punish ravishers and adulterers. The circumstances are precisely the same with all the cerebral organs of propensity.

propensities and powers, we know how much various circumstances influence the development of faculties and the strength

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answered Tiedemann, in l. c. 8vo. t. iv. p. 42.) 36. sq. 165. 212. 219, 220., vol. ii. p. 247.) He is unjust towards Dr. A. Combe and Mr. W. Scott, in vol. ii. p. 165. 196. sq. He stands at an immeasurable distance below Gall in intellect: and, though I believe him to have collected far more facts and contributed far more to the solidity of the science than Dr. Spurzheim, his intellectual powers have not Dr. S.'s strength. Nothing can be weaker than some of his remarks on vitativeness (vol. ii. p. 160. sqq.), concentrativeness (vol. ii. p. 212. sqq. also compared with p. 407.), and on alimentativeness (p. 173. sq.), on materialism (vol. i. p. 32. sq. compare with p. 223. and vol. ii. p. 50.), and on marvellousness (vol. ii. p. 427. sqq.). There are instances of bad taste, incorrect information, and carelessness, which vex me in so important a work. He agrees with Dr. S., in considering Gall's sense of persons as a sense of form, and yet all his facts and reasoning relate to persons. He adopts all the faculties alleged to be discovered by Dr. S. and others, and even adds three of his own — the sense of distance, of beauty in the arts, and the disposition of flocks or swarms to arrange themselves in regular figures. His remarks against Dr. S.'s views on acquisitiveness, secretiveness, cautiousness, eventuality, mirthfulness, and ideality, to use Dr. S.'s terms, are really good, and such as I have always made. He, in several instances, is just towards Gall, where others have been unjust. (See vol. ii. p. 393. 459.) And, although he rectifies Gall's localisation of most of the organs in brutes, and this with rude remarks, he once does him ample justice. (Vol. ii. p. 262.) "If Gall has not treated the phrenology of brutes as he might have done, he will always have the merit of having put his successors in the right road. This celebrated man, in developing his philosophical ideas by the aid of comparative anatomy and physiology, has left an immense distance between himself and Spurzheim, and all phrenologists who have not, like the latter, followed in his path. Time, which gives every man his proper place, while it will show us the imperfections of his works, will inevitably do justice to the extent of his views." He makes a few rectifications of the situations of organs in man; but his merit is that of having given to phrenology an immense mass of additional proofs from brutes, and observed and communicated his facts with, as it would appear, the minutest accuracy. No one can pretend to a perfect knowledge of comparative anatomy and physiology, without a knowledge of his labours, and to impress their importance upon my readers, I shall quote a long passage.

"In animals of the lower classes, to begin with fish and reptiles, the number of cerebral faculties is small; their acts generally of short duration: all have a spinal chord. In the apparatus of the senses they have, externally, a multitude of shades of form and structure calculated to facilitate their actions. The most prominent cerebral faculties are conservation, alimentation, and reproduction. If there are any perceptive faculties, they are, except in some species, very limited.

"What a difference, in this respect, between them and birds! How must

of dispositions, and we feel as if we were free agents: we seem to move our right hand or our left, and to sit still or walk, exactly as we choose; and we possess reason and conscience to guide our conduct.

Yet, notwithstanding this *feeling* of freedom, "all theory is," certainly, as Dr. Johnson said, "against the freedom of the will." [p]

The truth is, that we act necessarily according to the strongest motive; our liberty consisting, as Voltaire says in his charming article on Liberty [q], in the power of doing what our will requires of absolute necessity. Johnson, therefore, added correctly,

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we be struck with admiration on observing that, with the more energetic and complicated actions of birds, the cerebral system becomes more ample! Is it not still more surprising to see the combination and energy of the faculties perfectly coincide with the wants of the species? How can we, on the other hand, refuse to be convinced of phrenology, when it proves to us, by the inspection of many thousands of skulls, that if birds, whatever be their class, order, genus, or species, or even their peculiar habits, have a faculty in common, for example that of migration or recognising places, their skulls will always resemble one another at one point; and, as this truth applies to all the faculties discovered by observation, to deny the existence of these facts is to deny that the eye is the external apparatus of sight, the ear of hearing, the nose of smelling, &c.

"In quadrupeds and quadrumana, in which the cerebral operations, generally considered, are more numerous and present a more continued action than in birds, we find the cerebral system more developed. Some organs, which were but rudimentary in the two first classes, are very prominent; and the acts dependent upon them, being more energetic, confirm the general law of nature, — the relation between the extent and force of the acts of the nervous system with its volume or development." "Full and perfect reliance may be placed on my observations; for they are the result of a scrupulous and conscientious examination of many thousand skulls of brutes, and the dissection of their brains, subsequent to the study of their most striking manners and habits."

[p] Boswell's *Life of Johnson*, vol. iii. p. 294.

Consult Gall on *Materialism, Fatalism, and Moral Liberty*, l. c. 4to. vol. ii. from p. 79. to 132.; and on *Reason, Will, and Free Will*, vol. iv. p. 340. sqq.; and on *Free Will and Liberty*, 8vo. t. i. p. 228. sqq., and t. vi. p. 427. sqq., especially on *Illusory Liberty and Moral Liberty*. All these writers, however, were anticipated in "*A Philosophical Enquiry concerning Human Liberty*, by Anthony Collins. London." Collins again owes his views to "*A Treatise of Libertie and Necessitie, wherein all Controversie concerning Predestination, Election, Free Will, Grace, Mercy, Reprobation, &c. is fully decided and cleared*, by Thomas Hobs. London, 1654."

[q] *Dictionnaire Philosophique*.

"All experience is for it." And on another occasion said, "We know that we are free, and there is an end on't."[r]

Motives depend upon original organisation, sometimes modified by physical influence, internal or external; and upon external moral influence upon our mental organs.

The being who has the most faculties, the greatest equipoise of his faculties, and the most knowledge, has the greatest range of liberty.[s] If a person acts wickedly or absurdly from hearing necessity advocated, it is because certain motives become extinguished in him and his range contracted.[t] It results that we should educate, and give as many and as good motives as possible; and, when we punish, we should punish, not from presuming we have a right to condemn, but for the purpose of giving additional motives to good conduct, where there has clearly not been enough of them.[u] As the strength of individual inclinations and the facility of yielding to them are greatly increased by habit, in order that those of a lower class should not acquire undue force, nor

> "Upstart passions catch the government
> From reason, and to servitude reduce
> Man, till then free,"[x]

the necessity for education to consist not of mere precepts and sermons, but of good actions, is apparent. One good act may be more improving than the precept read or heard twenty times.

[r] l. c. vol. ii. p. 74.

[s] Voltaire, in the article referred to, makes *B.*, the person who is ignorant of the subject, say, "Mon chien de chasse est aussi libre que moi; il a nécessairement la volonté de courir quand il voit un lièvre, et le pouvoir de courir s'il n'a pas mal aux jambes. Je n'ai donc rien au-dessus de mon chien: vous me réduisez à l'état des bêtes.

To which his better informed friend, *A.*, replies, "Voilà les pauvres sophismes des pauvres sophistes qui vous ont instruit. Vous voilà bien malade d'étre libre comme votre chien. Ne mangez-vous pas, ne propagez-vous pas comme lui, a l'attitude près? Voudriez-vous avoir l'odorat autrement que par le nez? Pourquoi voudriez-vous avoir la liberté autrement que votre chien?

B. "Mais j'ai une âme qui raisonne beaucoup, et mon chien ne raisonne guères. Il n'a presque que des idées simples; et moi, j'ai mille idées métaphysiques.

A. Eh bien, vous êtes mille fois plus libre que lui; c'est-à-dire, vous avez mille fois plus de pouvoir de penser que lui; mais vous n'êtes pas libre autrement que lui."

[t] See Bishop Butler's remarks on the mischief of the doctrine, *Analogy*, p. 1. chap. vi.

[u] Gall, l. c. 4to. vol. ii. p. 100.; 8vo. t. i. p. 289., t. vi. p. 438.

[x] *Parad. Lost*, xii.

The objections on the ground of *materialism* are not more applicable to phrenology than to the doctrine now universally admitted, — that the brain is the organ of the mind; and they have been answered.

Those who have so little soul as always to ask what is the good of *any* discovery in *nature*, may be told that phrenology may be of much service in confirming some moral views which good sense may previously have suggested. Humility and benevolence are two leading duties. If we detect the signs of intellectual deficiency and vice in our own heads, we may learn to think humbly of ourselves; and, being put in possession of true self-knowledge, endeavour to strengthen what is too weak and repress what is too strong. If we detect the signs of great talents and virtues in the heads of others, we may love them the more as superior and highly favoured beings: whereas, if we detect the signs of great virtues and talents in our own heads, we may learn to give no praise to ourselves, but be thankful for the gift; and, if we detect the signs of vice and intellectual deficiency in others, we may learn to pity rather than to censure. Not revenge, but example, is the professed, and should be the sole, object of our legal punishments; — example to the culprit himself and others, or, if the punishment is capital, to others only; and therefore frauds, which, from being very easily committed, may become very detrimental to society, are punished more severely than those which, cæteris paribus, from being difficult of perpetration, can scarcely from their frequency become dangerous. Were moral demerit regarded, the fraud easily committed would, cæteris paribus, be punished the most lightly. A vicious man must be restrained, as a wild beast[y], for the good of others, though, for aught we know, his faults may, like the acts of the beast of prey, be chargeable rather on his nature; and, while we feel justified in confining, and the culprit is perhaps conscious how richly he deserves his fate, we may pity in our hearts and acknowledge that we ourselves have often been less excusable.

> "Teach me to love and to forgive,
> Exact my own defects to scan,
> What others are to feel, and own myself a man." [z]

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[y] A man of determined bad principle may in like manner be shunned by the most benevolent, on account of being odious and dangerous; though they wish him so well as ardently to long for his reformation, and pity his organisation, his education, and the circumstances under which he has been placed.

[z] Gray, *Ode to Adversity*.

Morality is inculcated by phrenology in the most striking manner. The faculties common to us and brutes are placed the lowest; the superior faculties above: as though the former should be subjected to the latter. We learn from phrenology what several faculties do certainly exist: and, as nothing exists but for a good purpose, each should be allowed to act. But they should be allowed to act harmoniously, — not one in opposition to another: the love of property not be allowed to oppose benevolence or justice, nor any one intellectual faculty to supersede the employment of the others. The greater the cultivation of all the intellectual faculties, the more abundant will be the motives of thought and action, — the freer the will: and the more the moral faculties situated superiorly are cultivated, and the fewer provocations are applied to the inferior, the more will the former guide the individual to his own happiness and that of others.

Phrenology, too, may be of the highest use when in criminals there is suspicion of idiotism or insanity. Idiotism often depends on deficiency of cerebral development, and many idiots have been executed for crimes when it was not exactly proved that they were idiotic enough to be unfit for punishment, but whose cranial development might have settled the point at once. Many persons also have been executed who should have been considered madmen, but were not because the fact of illusion was not made out: yet the extreme preponderance of the development of the organs of the propensities over that of the moral sentiments and intellect would have proved that they were deserving of coercion rather than punishment. Such does the skull of Bellingham, the murderer of Mr. Percival, prove him to have been.

In placing confidence in others and forming connections, phrenology may be of the greatest use. We might often be at once certain of an intellectual deficiency or a moral objection. Many heads have the development of their various parts so moderate and nearly balanced, that the character will depend chiefly upon external circumstances; and such will never become remarkable. Although fulness of development does not, like deficiency, give a certainty of the internal force, because it may not depend upon brain or upon good brain; yet, when the person is known to be of sound body and mind, and not torpid, the force within will, in an immense majority of cases, be correspondent with

the fulness without.[a] Like many other phrenologists, and, indeed, like Gall himself, I have suffered from having yielded to

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[a] Gall divides men into six distinct classes in regard to the moral and intellectual faculties: —

"In the first class, the qualities and faculties which are the most elevated and are peculiar to man are completely developed, while the organs of the animal qualities and faculties have but a feeble degree of development and activity.

"In the second class, the organs of the animal faculties and qualities have attained a high degree of activity, while the organs of the qualities and faculties peculiar to man are but little developed and but little active.

"In the third class, the qualities and faculties common to animals and those peculiar to man have considerable development and activity.

"In the fourth class only one or some of the inclinations or talents is developed in an extraordinary degree, while the rest have only a moderate development and activity, and are perhaps below mediocrity.

"In the fifth class, one or some of the organs are but little developed and remain inactive, while the others are more favourably developed and active.

"Finally, in the sixth class, the organs common to animals and those peculiar to man are almost equally moderate."

"When the superior qualities and faculties more peculiar to the human species much exceed the inferior, the man will prevail over the animal. The internal movements and all the conduct of these men are conformable to reason, justice, and morality. To judge equitably of the weaknesses of others, to generously pardon offences, to tolerate with indulgence the errors of their minds, to act with integrity, always to labour for the general good, sacrificing their own interests, always to render homage to truth with a wise intrepidity, always to be above ingratitude and persecution, always to ascend from effect to cause, and thus always to shelter themselves from prejudice and superstition, &c. &c.— this is the natural tendency of these men, these models, these benefactors of our race.

"The contrary is the case with those whose organs of the animal qualities and faculties have a very considerable development and activity, while the organs of the superior faculties have but little development and activity. In these, all is subjected to sensuality and error. The animal impulses are numerous and violent; and defeat is the more to be apprehended in proportion as the superior faculties and external aid are the weaker. If unhappily the prevailing inclinations are of the number of those the excessive activity of which destroys social order, will the philosophic judge be astonished at those men too frequently becoming the victims of their organisation?

"When the qualities and faculties common to animals and at the same time those peculiar to man are equally active, men result who are placed between the man and the brute. They are stimulated by the one and warned by the other: often humiliated by the one and often exalted by the other; great in vice and great in virtue; in many points, they are excellence and wisdom itself; in many others, they are subject to the most deplorable weaknesses and vices. The most opposite qualities frequently render them the most problematical beings: such as

social impulses and neglected to pay proper attention to the organisation. But the phrenologist, and not phrenology, was in fault.

We learn how a person may lose his memory of names, and of nothing else; and how any one or a certain number of the intellectual faculties or moral feelings may be over-excited, diminished, or otherwise damaged: just as one part supplied by one nerve or set of nerves may be palsied, convulsed, or pained; and

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Louis XI., Charles V., Philip II., James II., Catherine de' Medicis, who were superstitiously devout, and at the same time the scourge of their subjects. These are the persons who most acutely feel the struggle of the two beings within them. It is Socrates, St. Paul, St. Augustin, who, having the severest battles to fight, may pretend to the most glorious victory of virtue.

"When one or some qualities or faculties, whether animal or human, are endowed with an extraordinary energy, while the others are only moderate, the result is great geniuses, great talents in a limited career, or certain inclinations, whether bad or good, predominant over the others. These talents and inclinations constitute the character of the individual, who will have the more difficulty to withstand their impulses in proportion as the other moral and intellectual powers are less active. You have the mere musician, mechanician, and impassioned poet; but you have also the libidinous, the quarrelsome, the thievish, who even, in certain cases, are so impassioned that the excessive activity of such inclinations degenerates into real madness, and deprives the individual of the power of controlling them.

"You see on the contrary, partial apathies, imbecilities, when, by the side of other qualities and faculties sufficiently developed, one or more organs are but little developed. With such an organisation, Lessing and Tichsbein detest music, Newton and Kant dislike women.

"Lastly, in the sixth class, is found the crowd of ordinary men. But, as the organs common to animals occupy the greatest part of the brain, these men remain limited to the sphere of the animal qualities; their pleasures are those of sense, and they produce nothing remarkable in any respect.

"These six divisions are mixed in a thousand modifications, as happens with all the great divisions of nature. We rarely find the organisation happy enough to bestow upon the faculties of a superior order an absolute power of impressing a favourable direction upon the inferior. We may, therefore, admit it as a truth established by the laws of organisation, that, among men, a very small number find in themselves alone sufficient force or motive to be a law unto themselves,— always to resolve upon acts conformable to the dignity of the most noble inclinations, sentiments, faculties of men." (8vo. t. i. p. 320. sqq. See also 4to. vol. ii. p. 133. sqq.)

Gall required Dr. Spurzheim to infuse order, system, and philosophy into his discoveries and views!

He belonged to the small and noble class. God grant that increased cultivation of man's higher cerebral faculties may enlarge it!

indications of treatment will arise from the fact, just as in the latter cases.

We learn how absurd in education it would be to attempt the production of great excellence of a particular kind, on the supposition that he who can excel in one thing can excel in another, as though it were true, in Dr. Johnson's words, that "Genius is general powers applied to a particular subject;" or that, as Mr. Dugald Stewart said, "particular excellence is the result of particular habits of study or of business." We know by phrenology that all cannot do all; that the most unfit for one thing may be the most fit for another; and the organisation will indicate from whom we can expect nothing, and when we may hope for success. Punishment will not be inflicted, nor irksome studies enforced, where nature is at fault and the faculty is not strong enough from deficiency of organ. We are enabled to decide when the pupil is anxious for excellence through good feeling or conceit, and yet cannot by nature succeed in the particular branch which attracts him. We are enabled to adapt our moral management accurately to the moral qualities of each child.

In short, in every thing human, by knowing that various intellectual and moral faculties exist, by knowing what these are, by knowing accurately in general in what positive and relative strength they are supplied to particular individuals, we are enabled to act like philosophers, and not with that ignorant brutality which has hitherto so much disfigured the education and legislation of the world, as well as private conduct in society.

Gall made this noble and philosophical application from the first, as will be seen in both his works.[b] Others make them daily.[c]

By phrenology the true mental faculties have principally been discovered; and, as it shows the true nature of man, its importance in medicine, education, jurisprudence, and every thing relating to society and conduct, must be at once apparent.[d]

[b] l. c. 4to. vol. ii. p. 133—212., 8vo. t. i. p. 319—457., and both works *passim*.

[c] See Dr. Spurzheim's writings; Mr. Combe's *System of Phrenology*, and his *Essay on the Constitution of Man;* Dr. Combe's work on *Insanity;* Mr. Simpson on *Education;* and the *Edinburgh Phrenological Journal, passim.*

[d] I shall end the subject of Phrenology with one of those beautiful passages with which Gall's works abound.

"I have always been conscious of the dignity of my researches, and of the

While the brain is evidently the organ of mind, the nerves united with it, and the spinal chord, together with its nerves, are as evidently the instruments by which it affects, and is affected by the other parts of the body, to which these nerves are distributed. By their instrumentality, the brain contracts the voluntary muscles, influences the functions of every other part when under the operation of the different passions, and receives impressions made upon every other part.[e] The consequences of divisions of the nerves or spinal chord, fully substantiate these points.

If a nerve supplying an organ of sense, as the olfactory, optic, acoustic, or gustatory, is compressed or divided, the organ becomes insensible to odours, light, sounds, or tastes. If one exciting muscles only, as the common motor oculi, — the internal — or the external motor, — the facial — or the hypoglossal, the will loses power over such muscles;—over the inferior, superior, and internal

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extensive influence which my doctrine will one day exert upon human knowledge; for which reason I have remained indifferent to all the good or evil which might be said of my labours. They were too far removed from received opinions to be relished and approved at first. A knowledge of them required profound and continued study: every one wished to pronounce upon them, and every one came with opinions and views according to his means of intelligence. All the doctrine is now consecrated to the public. Judgment cannot long remain doubtful. Personal feeling will disappear: the passions will calm, and criticism will have only its due weight. Posterity will not fail to contrast the point from which I started with that at which I stopped. My adversaries have but too distinctly displayed the state in which the various objects of my labours were, for it to be difficult to know what improvement these have derived and will derive from my discoveries. What progress in the comparative anatomy, physiology, and pathology of the nervous system! What a fruitful source of irrefragable principles for philosophical studies; for the art of learning the disposition of individuals to the best advantage; for the art of directing the education of youth! What valuable materials for criminal legislation, based upon a complete knowledge of the motives of human action! How history will change in the eyes of those who will know how to value it according to the predominant inclinations and faculties of the personages who have played the chief parts in it," &c. (l. c. 4to. vol. iii. p. xii. sq., 8vo. t. vi. p. viii. sq.)

[e] In strict language, no part of the body but the encephalon, or what corresponds to it in lower animals, can have sensation. The different parts may be so affected, that, by the intervention of nerves between them and the encephalon, the latter perceives the impression made upon them; but the *sensation* is in the encephalon, although instinctively referred to the spot which is its *source*.

straight muscles of the eyes, the inferior oblique, and the levator palpebræ superioris,—the superior oblique,—the abductor straight muscle, — many muscles of the face, viz. the orbicularis, levator anguli oris, &c. &c. — or the muscular fibres of the tongue. If the spinal chord, or nerves conveying both volition from the brain and impressions to the brain, the supplied parts lose both sense and motion.[f] For when nerves both convey volition and supply common sensibility, as the fifth and the spinal nerves, they are compound, one portion performing but one function, as is proved by separately dividing the anterior and posterior part of the trigeminum, or the nervous bands, proceeding from the anterior and posterior parts of the spinal chord, before their conjunction; when the division of the former deprives the parts supplied of the influence of volition, and that of the latter deprives them of sensation. In the case of either these compound or the simply motor nerves, if the divided surface, now unconnected with the brain, is irritated (or if, indeed, the parts are not divided, but at once irritated by pinching), contractions occur in the muscles supplied by them; and, if a sedative is applied to them, some say that the muscles become inert. In the case of the compound nerves too, and in the case also of the division of those nerves which have common sensibility or touch and constitute a part of compound nerves, if the divided surface connected with the brain is irritated, acute pain is felt, as if in the part on which the nerve originally terminated[g]; and, after the removal of a limb, it is common for uneasy sensations to be experienced by the patient as if he still possessed his hand or his foot. The nerves which convey volition only, and

[f] These facts are too frequently proved to be doubted; and, consequently, four cases, in which the spinal chord is said to have been divided without the effect of paralysis, must be suspected of error. (See Metzer's *Principes de Médecine légale*, translated, with notes, by Ballard, p. 357. sq.) Another has been quoted from Dr. Magendie's *Journal de Physiologie*, t. iii., in which the *arms* were paralysed as to motion, and the lower cervical and upper dorsal chord was a colourless pulp, except two bands between the anterior fissure and the sides; so that the anterior portion of the chord was continuous (p. 184.), though the posterior was destroyed at one part. But the description is imperfect. Dr. Magendie suggests that the membranes carried on sensation!

[g] Thus, after the loss of the glans penis, the extremities of the nerves are sensible to venereal pleasure, as noticed by John Hunter and Dr. Marshall; and I once had an out-patient at St. Thomas's Hospital with gonorrhœa, and only an inch of a remnant of penis.

those of the other four senses than touch, — the nerves of the specific senses, — feel little or no pain when mechanical stimulus is applied; and these generally have not, like those which furnish and possess common touch or common sensibility, and perhaps all those of the specific senses, a ganglion at a certain distance from their origin.[h] There is Gasser's ganglion for the trigeminum, the posterior and larger part of which, including the ophthalmic and superior and inferior maxillary, gives sensibility to the face, and even what common sensibility they possess to the nerves of the specific senses and of motion; while the anterior and smaller part is not united with Gasser's ganglion, and is a nerve of motion to the muscles of the lower jaw, and some others of the face. There is a ganglion for each posterior nerve of the spinal chord.[i] The anterior

[h] See Dr. Magendie's *Précis de Physiol.* t. i. p. 200. sq. ed. 3.

[i] The branch of the trigeminum unconnected with the ganglion was declared to be a nerve of motion only, and to belong to the various muscles of the lower jaw, by Dr. Paletta in 1784: and was, therefore, called nervus masticatorius by Dr. Bellingeri in 1818. (*Dissert. inaug.* Taurini, 1818.) Dr. O'Beirne has shown that the motor portion is more extensively distributed in the muscles of the face; that, after uniting with the inferior maxillary of the ganglionic portion, so that the two are intimately mixed and all the subsequent branches are compound nerves one of which becomes attached to the superior branch of the facial, it is distributed to many muscles of the face besides those of the lower jaw. He hence explains some instances of a certain loss of motion after injury of the ganglionic portion of the fifth, and of continuance of motion after injury of the facial; — paralysis of the motor branch of the fifth being attended by distortion of the face while the patient is at rest, and less when he speaks, laughs, &c. and thus puts in action the muscles supplied by the facial nerve; paralysis of the facial being attended by distortion only when he puts these in action; and paralysis of both being attended by constant distortion and an increase of it during these actions. He shows with great acuteness how unsatisfactory and erroneous are many of Sir C. Bell's views and statements respecting paralysis of the face. (*New Views of the Process of Defecation*, p. 227. sqq.) Dr. Bellingeni appears to have had some vague notion of the functions of the anterior part of the trigeminus and of the facial nerve; but, since he says that the facial nerve gives animal sensibility as well as motion to the muscles and integuments of the face (p. 124.), and speaks of the upper branch of the trigeminus as exciting involuntary motion (p. 177. sqq.), I cannot believe that he anticipated Sir C. Bell, who certainly appears to have discovered step by step the office of the ganglionic portion of the trigeminum, and proved that this was a double pair for sensation and motion — the portion devoted to sensation having a ganglionic enlargement, the other none, exactly like the spinal nerves; although its similarity in structure to the spinal nerves he candidly states to have been pointed out by Prochaska half a century ago, and by Sömmerring. (*The*

portion of the spinal chord is nearly insensible, while its posterior portion, and all the ganglionic branches of the trigeminum, are

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Nerv. Syst. of the Hum. Body, 1830, p. viii. In this work are various papers presented by him to the Royal Society during the preceding nine years.) Sir C. Bell also discovered the facial to be a nerve of motion only, though, besides speaking of it as a nerve of voluntary motion, he gave it some properties of expression which are common to all nerves of voluntary motion, and strangely called it a respiratory nerve. Our knowledge of the functions of the anterior and the posterior or ganglionic portion of the spinal nerves, we owe first to Sir C. Bell, and next to Dr. Magendie. In a tract privately circulated by Sir C. Bell in 1811, he stated that, on dividing the posterior spinal nerves, no motion ensued; but that, on touching the anterior, the muscles of the back were instantly convulsed. (p. xvii. sq.) He concluded that the anterior and posterior portions had different functions, and that the anterior gave motion; but he went no farther: and even fancied that the anterior gave sensibility also, and that the posterior might have other functions altogether. Dr. Magendie, many years later, proved that the anterior nerves gave motion only, and the posterior sensation. (*Journal de Physiologie,* t. ii.) Had Sir C. Bell been aware of these, — the true functions, — he would not have neglected to set forth a discovery which he views in his later writings as so great.

While a branch of the trigeminum was supposed to be a nerve of taste — a special sense, — there was a great want of uniformity in our views of its offices. It resembled the spinal nerves, in having a ganglionic and an aganglionic root. The aganglionic had been shown by Paletta to be for motion only. Every body knew that the ganglionic portion was for sensation. For example, Blumenbach said, when treating of smell, that the first pair was for this sense, but the trigeminum for the common sensibility of the nostrils. Still the ganglionic portion was thought to be a nerve of motion also, and this was Sir C. Bell's opinion; for his first experiment seemed merely to corroborate the common belief, that the ganglionic portion was for sensation and motion. After he had made many experiments he concluded it was for sensation only, and, although he is right in regarding it as a nerve of sensation only, he and others appear incorrectly to ascribe a number of facts regarding paralysis of motion in the face to the seventh, that really depend upon the trigeminum, though not upon the ganglionic portion but upon the aganglionic portion, as Dr. O'Beirne has so well shown. In fact, the truth of the ganglionic portion of the trigeminum being for sensation only was in some measure incorrectly inferred by Sir C. Bell from his experiments and cases, exceptions being passed over or unsatisfactorily explained. They all admit, however, of easy explanation, by referring impairments of motion on dividing the ganglionic branches to the extensive ramifications of the aganglionic portion in conjunction with those of the inferior maxillary branch; and, where any paralysis of motion appeared on dividing the superior maxillary branch, to the necessary injury of one head of the levator labii superioris alæque nasi. From reviewing every circumstance, there can be no question that Sir C. Bell's view, of the ganglionic portion being for sensation only, is true. Still he has left

acutely sensible: the division of the former portion has the same effect as the division of the anterior nerves; of the latter, as the division of the posterior nerves. The destruction of the centre of the spinal chord by a wire impairs neither sensation nor motion[k], nor is pain felt by the experiment: and I may remark that, in experiments on the healthy cerebrum and cerebellum, no

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the matter confused and anomalous, by assuming the general belief of a branch of this nerve of common sensation or touch serving for a special sense, — for taste. The perfect analogy of the trigeminum to the spinal nerves in having one of its two divisions for common sensation only and one for motion is now established by Professor Panizza, through his demonstration of the glosso-pharyngeal being the nerve of the special sense of taste, while the branches of the trigeminum going to the tongue are for its ordinary sensibility, just as those which go to the mucous membrane of the nose endow it with the same common sensibility, while the olfactory endow it with its special sense of smell. (See *infrà*, Chapter XXI. On Taste.)

Dr. Magendie, finding that the division of the trigeminum deprived the nose, eyes, &c. of the sense of touch, so that acrid substances no longer irritated, concluded that it gave smell, sight, and taste, and threatened to overthrow the doctrine of the optic nerve being for sight, the olfactory for smell, and so on. He mistook the loss of common feeling for the loss of the specific sensibility of the eye, nose, &c., and his conclusions have long fallen to the ground.

The opinion that there are distinct nerves for sensation and for motion had been entertained ever since the time of Erasistratus by many writers, from the fact of paralytic limbs being sometimes deprived of sensation only, sometimes of motion only, or even, in the latter case, becoming more sensible than previously. In Pouteau's *Œuvres Posthumes*, published in 1783, vol. ii. p. 532., it was maintained, but the author remarked that it had long been abandoned by anatomists. He erred in supposing that the nerves of sensation came from the cerebrum, and those of volition from the cerebellum: as Galen erred in saying that the nerves of sensation arose from the brain, and those of voluntary motion from the spinal chord. Certain nerves were known to be for sensation only, as the olfactory, optic, and acoustic; some for motion only, as the common motor of the eye, the external and internal motor. Sömmerring had pointed out that one nerve gave motion to the tongue, another sensation: whence a man might lose his taste and yet move his tongue as before (*Hirn und Nerven*, p. 255.); and Gall, in 1810, urged that his adversaries would find it difficult to prove that the same nervous filament possessed the power of both feeling and motion; and that the trigeminum pair, which supplies both sense and motion, has three distinct roots. (*Anatomie et Physiologie*, t. i. p. 129. sqq.) The morbid sensibility to warmth occasionally observed in paralysis, although the sense of touch be not morbidly acute or be actually impaired, induced Dr. Darwin to fancy there were distinct nerves even for the sensation of temperature. (*Zoonomia*, Sect. xiv. 6.)

[k] Dr. Magendie, *Journal de Physiol.* t. iii. p. 153. sq.

sign of sensibility appears on cutting the former to a great depth, or the latter superficially. But the division of the trigeminum, on the sides of the fourth ventricle, has all the effects of its division without, and severe pain attends injury of the interior and sides of the fourth ventricle[l], except as you approach the anterior part of the spinal chord; and there is little sensibility at the corpora quadrigemina. The effects of the division of the spinal chord are of course more extensive in proportion as the division is made higher up; and, if made above the origin of the phrenic nerves, which are the chief agents in causing the contraction of the inspiratory muscles, and consequently above the origin of all the nerves of inspiration, death immediately ensues.[m] Yet, in brutes, after removing the head or dividing the spinal chord, if any limb is irritated, its muscles are thrown into action: thus Sir Gilbert Blane, after such operations in kittens a few days old, found the hind legs to shrink from the touch of a hot wire applied to the hind paws; and the tail to move when irritated, after the division of the chord below the last lumbar vertebra.[n] More divisions than one do not prevent this effect. If the head of a pigeon is cut off, and the whole brain removed except a portion to which the third pair is attached, and the optic nerve is divided, the iris instantly contracts when the extremity of the optic nerve is pinched.[o] Dr. Macartney says that contraction of the iris occurs from light suddenly admitted to the retina after the head is cut off or the eye taken out.[p] Dr. Magendie also remarks that, when the posterior roots of the spinal chord are irritated, besides signs of extreme pain, the muscles below the part irritated are thrown into action, but only on the same side of the body. All these facts show a peculiar relation between the nerves of

[l] Dr. Magendie, *Précis*, t. i. p. 237. 3d edit.

[m] It is thus that animals are every day killed by pithing; in Germany I have never seen oxen killed in any other way: a blow on the back of the neck is sufficient to destroy rabbits. Livy informs us that, at the suggestion of Asdrubal, in the battle in which he was slain, when the Carthaginian forces were routed, and their elephants became unmanageable, the drivers destroyed them in a moment by one blow of a hammer upon a knife fixed between the junction of the head and spine. (*Histor.* l. xxvii. c. 49.) The division of the phrenic nerve only does not put a stop to respiration. See for instance, Bichat, *Recherches Physiol.* p. 327.

[n] *Select Dissertations on several Subjects of Medical Science.* By Sir Gilbert Blane, Bart. M.D. London, 1822. p. 262.

[o] Mr. Mayo, l. c. p. 231.

[p] *Report of the Third Meeting of the British Association*, 1834, p. 53.

sensation and motion that originate at the same portions of the nervous system.[q]

If the chorda oblongata exists, consciousness and volition become evident. Mr. Lawrence saw a child with no more encephalon than a bulb, which was a continuation for about an inch above the foramen occipitale from the chorda spinalis, and to which all the nerves inclusively from the fifth to the ninth pair were connected.[r] The child's breathing and temperature were natural; it discharged urine and fæces and took food, and at first moved very briskly, and lived four days. M. Lallemand saw such another which lived three days, and cried loudly.[s] M. Ollivier one which not only cried and sucked, but squeezed strongly what was put into its hand.[t] Unfeeling vivisectors, however, have not been contented with such facts supplied by nature, but have repeated them by the knife, and found that, if the cerebrum and cerebellum are removed in a living mammiferous brute, and the same portion of the chorda oblongata left, the poor thing cries on attempts being made to give it pain by pulling its whiskers or applying pungent things to its nose or mouth, and it moves its extremities, in order to escape from its annoyances, sometimes for two hours.[u] An adult hedgehog gratified Dr. Magendie by doing all this for two hours. Cold-blooded animals live much longer; and, the lower we descend in the scale of brutes, the more diffused appear the powers of the nervous system: indeed, in the lowest there is, strictly speaking, no brain nor spinal chord, but nervous granules, or distinct ganglions and nerves,

[q] *Journal de Physiologie*, t. iii. p. 154.

Dr. Magendie, with Desmoulins, asserted that the spinal nerves of the python thus sprang from but one root. But Mr. Mayo found them arise from two, as in all the vertebrated animals. (*Outlines*, p. 254.)

[r] *Medico-Chirurgical Trans.* vol. v. p. 166. sqq.

[s] *Obs. Path.* p. 86.

[t] *Traité de la Moelle Epinière*, p. 155.

[u] *Anatomie du Syst. Nerv.*, par MM. Magendie et Desmoulins, p. 560. Dr. Magendie, for whose head the dogs, cats, and rabbits of France would in his active days have offered a reward, if they had known their own interest, says, "It is droll to see animals skip and jump about of their own accord, after you have taken out all their brains a little before the optic tubercles." And as to "new-born kittens," he says, "they tumble over in all directions, and walk so nimbly, if you cut out their hemispheres, that it is quite astonishing." (*Journal de Physiologie*, t. iii. p. 155.) Above a century and a half ago, — in 1673, M. Duverney removed the cerebrum and cerebellum from a pigeon, and found the animal "live for some time, search for aliment, &c." (*Phil. Trans.* vol. xix.)

which, no doubt, perform the same functions as far as required in those animals, and are, in fact, some at least, brains also to them, but of a different form and accommodated to their structure.[x] In the same way the heart is not one mass in the cuttle-fish but three, and in the lowest none exists,—vessels carrying on the circulation. It was, not many years ago, customary to assert that many animals have no nervous system. "It was reserved for the modern spirit of observation," says Professor Tiedemann, "to establish the presence of nerves in many of the most inferior animals—the star-fish, actinia, pyrosoma, ascidia, and some entozoa, in which their existence was denied in Haller's time."[y] Professor Ehrenberg has lately shown that the infusory animalcules possess nerves and even ganglia, as well as eyes, muscles, and sexual and digestive organs, and probably vessels, though myriads can exist in a dot: the verticella rotatoria being only from $\frac{1}{300}$ to $\frac{1}{400}$ of an inch in dimension.[z] In regard to brutes in which nerves are not yet found, Dr. Tiedemann allows that, "as we perceive in these animals phenomena which take place by the medium of nerves in animals of a more elevated order — that is to say, sensibility and voluntary motion — it is not improbable that, in them, the nervous substance is mixed with the gelatinous or mucous mass, without being demonstrable as a particular tissue."

The higher we ascend, the more parts exist above the chorda oblongata, till, rising from fish and reptiles, through the numerous warm-blooded brutes, all distinguished by the relative magnitude of each cerebral part, according to their several mental characters, and seeing the successive additions of cerebral structure and cerebral mass, and of intelligence, we arrive at man, in whom the successive impositions of cerebral matter has reached its maximum, so that the summit of the nervous system, which corresponds with the forehead and vertex, is much larger in him than in any brute[a], and his intellect and moral feelings are proportionally

[x] Gall, l. c. 8vo. t. i. p. 25. sqq.

[y] *Systematic Treatise on Comparative Physiology*, by F. Tiedemann, M.D. Prof. of Anat. and Phys. in the Univer. of Heidelberg, translated by G. J. M. Gully, M.D., and J. H. Lane, M.D. 1834, p. 64. See my remarks, *suprà* [e], p. 4.

[z] See accounts of Prof. Ehrenberg's discoveries by Dr. Gairdner, and my colleague Prof. Sharpey, in the *Edin. New Philos. Journal*, 1831, 1833.

[a] See Gall, l. c. 4to. vol. ii. p. 252. 364. sqq.; 8vo. t. ii. p. 153. sqq. 365. sqq., t. vi. p. 298. sqq.

greater.[b] According to the smallness of the anterior and anterior-superior portions of the brain, will individual mental superiority to the brute creation be small. Human idiotism may arise from faultiness of texture, or want of power[c], but most congenital cases depend upon deficiency of anterior development; and such idiots, as well as the whole brute creation, may be regarded as examples of cerebral mutilations, made by nature, illustrating the use of the cerebral parts. Attempts to mutilate artificially are not calculated to afford much information. Brutes can generally give no opportunity of minutely observing what mental change has been produced by the removal. For instance, when a writer says that the removal of the cerebellum causes no other effect than sluggishness in the animal,—how does he know that sexual desire is not extinguished? When various portions of brain are removed, how can any inference be drawn, during the short existence of the poor animal, as to the state of its various faculties and inclinations? And when another asserts that, after the removal of the hemispheres and cerebellum, we may make observations whether the animal will copulate or not, how can he ascribe the disinclination that may occur to the removal, when any circumstances of suffering,—a wound, confinement, or want of food,—will make it very difficult to induce an animal to indulge itself with sexual intercourse?[d] It is, besides, difficult, if not generally impossible,

[b] In the words of the 94th Number (already quoted above at p. 329.) of the *Edinburgh Review*, now retracting its assertions: "In the nervous system alone we can trace a gradual progress in the provision for the subordination of one animal to another, and of all to man; and are enabled to associate *every faculty which gives superiority with some addition to the nervous mass*, even from the smallest indication of *sensation* and *will* up to the highest degree of *sensibility*, *judgment*, and *expression*. The brain is observed to be progressively improved in its structure, and, with reference to the spinal marrow and nerves, augmented in volume more and more, until we reach the human brain, each addition being marked by some addition to, or amplification of, the powers of the animal, until in man we behold it possessing some parts of which animals are destitute, and wanting none which they possess."

[c] Gall, 8vo. t. ii. p. 377.

[d] See Gall, l. c. 8vo. t. vi. p. 210. From page 178. to 288. are excellent remarks upon the unsatisfactory nature of such experiments as have been made by Fleurens, Rolando, &c. &c. See also 4to. vol. iii. p. 56., and 8vo. t. iii. p. 379. sqq. The first three quarters of the sixth volume should be read by all who are acquainted with the writings of these experimenters, or of Tiedemann, Rudolphi, Serres, &c. upon the brain. They will find those writers less meritorious than they imagined.

to remove one cerebral organ entirely and alone. Other parts of the encephalon, &c., are almost certain to be injured[e]: and, if

[e] "Where is the anatomist or physiologist who precisely knows all the origins, the whole extent, all the ramifications, all the connections of an organ? You remove the cerebellum, at the same moment you severely injure the medulla oblongata and spinalis, you injure the tuber annulare, you injure the tubercula quadrigemina; consequently, your results relate not merely to all these parts, but to all those which communicate with them, either directly or indirectly. You think you have insulated the tubercles, but these tubercles have connections with the corpora olivaria, the medulla oblongata, the cerebellum, the sense of vision, and many convolutions; the thalami, optici, the corpora striata, are connected below with the crura cerebri, the tuber annulare, the medulla oblongata, the pyramids, and the spinal marrow; above, with all the cerebral membrane, all the convolutions, the non-fibrous, grey, substance of their surface, with the different commissures, as the anterior commissure, the great commissure or corpus callosum; with the fornix, the septum lucidum. Thus there does not exist a cerebral part which we do not know to have numerous connections with other parts. I do not except even the corpora mammilaria, the pineal gland, the infundibulum, &c. The connections yet unknown are unquestionably still more numerous." (Gall, l. c. p. 240. sqq.) Sir C. Bell has lately imitated Gall in objecting to vivisections as a means of discovery.* Gall's nature was most tender. He had a horror of inflicting pain upon poor brutes, and would allow Dr. Magendie to be little more than a canicide. He always kept birds and dogs in his house at Paris; and I have seen him kiss his horses on alighting from his carriage at his country house, and then stand to receive the caresses of several immense bloodhounds which put their fore legs upon his shoulders. (See his glowing remarks on cruelty to brutes, l. c. 4to. vol. iv. p. 196., 8vo. t. v. p. 259. sq.)

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* *Phr. Trans.* 1834. No doubt in complete ignorance of Gall's writings, because he says that "not one of the great divisions of the brain has yet been distinguished by its function," and alludes evidently to Gall's physiological discoveries as the "weakest fancies that ever obscured any science." He had said before that Gall's strictly inductive method "is the most extravagant departure from all the legitimate modes of reasoning;" that Gall, without comprehending the grand divisions of the nervous system, without a notion of the distinct properties of individual nerves, or having made any distinction of the columns of the spinal marrow, without having ascertained the difference of cerebrum and cerebellum, &c. (*Ph. Tr.* 1823.) Sir C. Bell must be in total ignorance of Gall's works, more especially as he adopts some of Gall's facts without mentioning his name. His folly as been exposed by Dr. Spurzheim (*Appendix to the Anatomy of the Brain.* 1830. p. 23. sqq.) It is delightful to find that, even in 1823, Sir C. Bell was harassed by the popularity of Gall's discoveries and the difficulty of keeping his pupils from being converts to phrenology. (*Nervous System*, p. 122.) We phrenologists, however, must console ourselves with reflecting that his ignorance is not confined to Gall's labours, as he disfigures the *Philosophical Transactions* (1834, p. 471.) by speaking of "*a* minute spicul*a*."

others should not be injured, they may be influenced by the extension of the irritation from the injury[f], and by sympathy with the injured parts; just, for example, as we see epilepsy from exciting causes in every part of the encephalon and from exciting causes even in distant organs; amaurosis is frequently induced by wounds of the supra-orbital nerve, sometimes by wounds of the infra-orbital nerve, and of the portio dura[g]; M. Fleurens declares that, in cutting the semicircular canals in which the acoustic nerves only are spread, peculiar motions occurred. If the horizontal canal on each side was divided, horizontal movement of the head took place from side to side, and rotation of the whole body. Division of the inferior vertical canals on each side produced vertical movements of the head, and caused the animal to lie on its back. Division of the superior vertical canals caused vertical movements of the head, but the animal lay forwards. The direction of the inferior vertical canal is backwards, and of the superior forwards. If all the canals were divided, all sorts of violent motions took place.[h] Some parts which have distinct names are only portions of organs, so that injury of several parts may have the same effect; — we may have blindness from wounding the optic nerves, the tractus optici, or the corpora quadrigemina. Some parts which have distinct names are compound, so that the immediate and obvious effect of injuring them is not the only consequence which would be observed if the others had an opportunity of becoming apparent. The chorda oblongata is an instance of this[i], and all the double nerves of sensation and motion.[k]

[f] See Gall, l. c. 8vo. t. iii. p. 409. sqq., where examples are given.

[g] See many cases in Mr. Wardrop's work, *On the Morbid Anatomy of the Eye*, vol. ii. p. 179. sqq. The fact is even mentioned by Hippocrates; and, what is singular, the blindness generally arises from an imperfect division of the nerve, and has been cured by making the division complete. The blindness has sometimes taken place instantly, sometimes come on very gradually.

[h] *Mém. de l'Acad. des Sc.* t. ix. p. 454. sqq.

[i] " The tubercula quadrigemina are a continuation of the bands of the medulla oblongata and medulla spinalis. They are also formed by ganglia, one portion of which gives origin to the fibres of the optic nerve.

" In the same manner, the medulla oblongata is in a great measure a continuation of the spinal marrow, besides containing many collections of non-fibrous substances, which, like so many ganglions, are the origins of many nerves of the highest importance, and relating to very different functions.

Hence the contradictory and strange observations and inferences of most experimenters on the brain of living brutes.[1] The

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" The tuber annulare is not only composed of the nervous bundles of the two hemispheres of the cerebellum, or of the commissure of the cerebellum, but is also a continuation of several bundles of the medulla oblongata and spinalis, of the anterior and posterior, or inferior and superior, pyramids, and contains a considerable quantity of non-fibrous substance interposed between the transverse and longitudinal bundles, and giving rise to fresh filaments for the crura cerebri, the tubercles," &c. (Gall, l. c. 8vo. t. vi. p. 243. sq.)

[k] " You cannot insulate even the nerves of sensation before they are complete. The origin of the nerves of taste is confused with the masses of the origin of many other nerves; the auditory is confused with the nervous and non-fibrous masses of the fourth ventricle; the optic nerves at first with all the mass of the tubercles, with the corpora geniculata and their attachments, with the crura cerebri, with the grey layer situated immediately behind their junction. The olfactory nerves are at first intimately connected with the grey substance placed upon the interior and inferior convolutions of the middle lobes, with the anterior cerebral cavities," &c. (l. c. 8vo. t. vi. p. 245.)

[1] Fontana says that, after removing the brain of a turtle and entirely emptying the cranium, the animal lived six months, and walked as before. M. Rolando attempted the experiment repeatedly, but the animal always died as soon as a cut was made behind the cerebellum.

M. Rolando says that he " made innumerable experiments upon goats, lambs, pigs, deer, dogs, cats, and guinea-pigs, to ascertain the results of lesion of the tubercles, and parts near the optic thalami, but rarely obtained the same results." M. Rolando says that lesion of the thalam optici causes convulsions; M. Fleurens denies it. (Gall, l. c. t. vi. p. 191.) M. Rolando found an unsteadiness like that of intoxication follow the removal of two thirds of the lobes of the cerebrum from a chicken. M. Fleurens declares that he must have wounded the cerebellum. M. Fleurens protests that the results of the experiments of M. Rolando are contradictory to each other (p. 215.): and, after finding a chicken walk, fly, and swallow, shake its wings, and clean them with its beak, subsequently to losing the hemispheres of its brain, infers that these are the residence of the understanding and feelings, and that the cerebellum is destined to balance, to regulate motion; yet birds, after losing these parts, pecked and clawed their enemies, and perched. (p. 266.) M. Rolando considers muscular action to depend upon the cerebellnm; yet Dr. Magendie found animals perform regular motions after losing it.

In the *Report of the Physiology of the Nervous System*, read at the British Association in 1833, in which Gall's name is not once mentioned, the compiler, after saying, " But there *does* appear sufficient evidence to prove that those volitions, which have motion for an effect, whatever be their origin, whether in the cerebrum, cerebellum, or medulla oblongata, require for their accomplishment the co-operation of the cerebellum," declares further on, that " a duck, whose cere-

same effects moreover do not occur in the same experiments upon different species of animals. The observation of nature's own mutilations in brutes which have little or no development of parts that are large in others, or in man, is therefore preferable; and next to this comes the observation of morbid changes of different parts,—a subject, however, incapable of affording information till the faculties had been ascertained by Gall. (See *suprà*, p. 349. sqq.) Still some results of mutilating the living brain appear generally allowed, and are not at all in contradiction to phrenology. The experiments of M. Fleurens are allowed by Gall to be very ingenious, and sometimes satisfactory[m]; and, with respect to injuring the cerebellum, Gall remarks, "we must never forget that the same part may have its general vital function and its particular animal function. If it is true that the lesion of the tubercles in birds always causes convulsions, it is not less true that the tubercles are destined to vision; and in the same way the cerebellum (connected as it is with the medulla oblongata, &c.) may participate in the vital function of the medulla oblongata and spinalis, may give rise to disturbed motion when injured, and yet have its

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bellum had been destroyed," by Dr. Magendie, "swam backwards,—could swim only backwards" (p. 69.): and Dr. Magendie shows that it is requisite to neither sensation nor motion; for, when, after having robbed hedgehogs and guinea-pigs of their cerebrum and cerebellum, he kindly held a bottle of refreshing vinegar under their nostrils, they rubbed their little noses with their paws! And he says that he has over and over again seen animals performing very regular movements after he had disburthened them of the whole of their cerebellum. (*Précis*, t. i. p. 408.) In opposition to M. Fleurens, MM. Foville and Pinel Grand-Champs ascribe to the cerebellum the function of sensation.

M. Fleurens, after removing the cerebrum, declared all sensation and volition to be lost. M. Bouillaud found animals so deprived give signs of pain and exert will in endeavouring to escape. (Dr. Magendie's *Journal*, t. x. p. 36. sqq.) M. Fleurens infers that the lobes of the cerebrum concur as a whole in their functions, and that, when one sense is lost, all are lost. But M. Bouillaud, on removing the anterior lobes, found that dogs, rabbits, pigeons, hens, saw, smelt, and moved voluntarily; but were indifferent to familiar sounds, persons, places, or things. In fact, he found Gall's assertion true, — that, though sensation was independent of the anterior part of the brain, the faculty called by Gall sense of things (objects as wholes), and those of language, places, and persons, were altogether dependent upon the anterior part. The result of M. Bouillaud's experiments made him a strenuous phrenologist.

[m] l. c. t. vi. p. 249.

own particular animal functions."[n] That animals should skip and jump, and eat, after losing their hemispheres, is not surprising, if these parts perform the phrenological functions assigned to them and are not necessary to motion. The chorda oblongata and other lower parts of the encephalon have, no doubt, much to do with motion as well as the chorda spinalis. Accordingly, when the oblongata was pressed in the child mentioned by Mr. Lawrence convulsions occurred; and the same effect ensued on irritating it, in Gall's experiments and those of Lorry.[o] Pressure of it, however, is also said by vivisectors to occasion stupor.

Dr. Magendie, who cut living animals here and there with no definite object, but just to see what would happen, informs us, that,

1. Deep cuts of the hemispheres do not affect motion in mammalia, reptiles, fish, and many birds, any more than their entire removal: but the latter is said to occasion blindness in mammalia and birds, though not in fish or frogs, probably from the arrangement of the cerebral parts being different, so that a similar wound affects different organs. Neither a longitudinal section of the mesolobe, nor its removal, has any more effect on motion.

2. If the *white* substance of both corpora striata is cut away with the hemispheres, the animal darts forward against all objects in its way, and retains the attitude of progression, if prevented.[p] If the injury is to the grey portion, or to the white of one corpus striatum only, motion is not interfered with. When a thalamus was removed from a poor animal moving forwards after this mutilation, it ceased to attempt advancing, but began to turn to the corresponding side; and, when the other thalamus was next cut away, it became still, with its head inclined backwards.[q] M. Fodéra had found that the removal of a part of the cerebellum

[n] l. c. t. iii. p. 385. sq. Dr. Vimont also conceives that the cerebellum is not simple. Finding its processus vermiformis very large in climbing and remarkably sure-footed animals, he imagines that it will be found somehow connected with motion. (l. c. t. ii. p. 242.) 1835. Mr. S. Solly lately stated to the Royal Society that he has traced a superficial and a deep-seated layer of fibres from the anterior columns of the spinal chord into the cerebellum.

[o] Gall, 8vo. l. c. t. iii. p. 392.

[p] Yet Drs. Foville and Pinel Grand-Champs fancied that the anterior lobes and corpora striata presided over the motions of the inferior extremities; and the posterior lobes and thalami over those of the superior.

[q] *Report of Brit. Assoc.* 1833.

always caused motion backwards, or a corresponding attitude. Injuries of one side of it paralysed the same side of the body, as the fibres of the restiform bodies do not decussate like the anterior pyramids.[r] But Dr. Hertwig asserts that injuries of the cerebellum affect the opposite side, just as Gall found removal of the testis affect the opposite lobe of the cerebellum. Dr. Magendie often found animals perform very regular movements after the removal of the cerebellum; yet he observed that the removal and wounds of it to a certain depth, and of the chorda oblongata[s], gave mammalia and birds a tendency to move backwards, though the same effect does not occur in fish, which, after the loss of their cerebellum, swim as usual.

3. In a vertical section of a crus of the cerebellum, or of the mesocephalon from before backwards, the animal immediately rolled forcibly towards the same side, making sometimes sixty revolutions in a minute; and the corresponding eye was directed forwards and downwards, the other backwards and upwards. After the division of a crus, animals continued rolling, and with their eyes thus directed, for eight days. If both crura were divided, all motion ceased, and the eyes resumed their natural state.[t] A similar vertical section downwards of the cerebellum from before backwards half way on one side of the central line, through the whole substance of the arch over the fourth ventricle, or of the mesocephalon upwards, had the same effects, and the motion was the more rapid as the section was nearer to the mesocephalon. When an incision of one half of the cerebellum had set an animal rolling to that side, an incision of the opposite crus arrested the rolling and caused the eyes to resume their natural position. A vertical incision downwards in the median line of the cerebellum caused the animal to attempt motion, but deprived it of the power of balancing itself. Its eyes rolled and started, and its fore legs were rigid and extended forwards.[u]

4. If the fourth ventricle is exposed and the cerebellum removed, a perpendicular incision in the chorda oblongata on one side

[r] *Journal de Physique,* July, 1823.

[s] If ever he amused himself by sticking pins in the chorda oblongata of pigeons, the birds thus ornamented by him would walk and fly backwards for above a month! (*Précis,* t.i. p. 409.)

t *Journal,* t. iv. p. 403.

[u] *Journal de Physiol.* t. iv. All these points were ascertained on noticing the effect of a wound made unintentionally in a crus.

of the median line, near the outside of the anterior pyramid, will cause a rabbit four months old to turn to the right, if made on the right side; and to the left, if made on the left.

5. Notwithstanding the decussation of the anterior pyramids, a division of one or both had no sensible effect, except, perhaps, that of retarding motion a little; the section of the corpora restiformia does not seem to affect general motion; and a complete division of one half of the chorda oblongata neither affects sensibility nor prevents irregular motions, though the power of volition appears lost on the same side.

The same phenomena occur in disease. Persons labouring under hysteria or chorea sometimes reel violently or spin round.[x] Persons have been known to feel an impulse to move forwards or backwards.[y] An infinite variety, however, of extraordinary and regular movements also occur, and frequently vertigo attends them, whatever their variety. Vertigo cannot be their cause, as they are so various in different cases, and they or it frequently exist alone.

From these experiments I draw no inference. The considerations already mentioned prevent me from concluding that the parts which are cut are the sole organs concerned in giving origin to the peculiar motions, that their sole purpose is for such motions, or even that peculiar motions depend originally upon them. We can only say, as in the undoubted and numerous cases of amaurosis following an injury of the supra-orbital or infra-orbital nerve, and as in regard to the peculiar motion said by

[x] See *Med. Chir. Trans.* vol. v. p. 1. sqq., also vol. vii. p. 237. sqq.

M. Serres mentions a drunken shoemaker who spun round till he died, and in whom the only morbid appearance was disease of a crus cerebelli. (Dr. Magendie's *Journ.* t. iv. p. 405. sq.)

[y] In a man who had an irresistible desire to move forwards, tubercles were found particularly at the anterior part of the hemispheres. (Dr. Magendie, *Journal de Physiol.* t. iii.) I have seen several epileptic youths with this propensity. They would walk away to a very considerable distance, without knowing why; and this repeatedly. A hemiplegic young man would walk upwards of 50 miles from home, and be lost for a considerable time. I frequently see persons with a propensity to precipitate themselves forwards. In some there is desire merely to leave their abode, and they walk to gratify this, or travel by some conveyance. Dr. Laurent exhibited a girl at the Académie Royal de Médecine, who, in irregular hysteric attacks, rushed rapidly backwards. (Dr. Magendie, *Précis de Phys.* p. 409. sq.)

M. Fleurens to occur on division of the branches of the acoustic nerve, that such effects ensue. In hemiplegia, disease is frequently found in a corpus striatum; and some have endeavoured to prove that paralysis of an upper or lower extremity is attended by disease in this part or that, but the coincidences are not such as to warrant any conclusion.

In fœtuses full grown, without encephalon or spinal chord [z], the circulation, nutrition, secretion, &c. proceed equally as in others, which, besides spinal chord, nerves, and ganglia, possess a brain.[a] These mutilations by nature are conclusive, and render all vivisections on the points unnecessary. Further, the heart and arteries are formed in the fœtus before the encephalon and spinal chord, and therefore cannot depend on them for power and excitement. Vegetables absorb, assimilate, circulate, secrete, and in many instances contract on the application of stimuli, and yet are not

[z] See Morgagni, *Ep.* 48. No. 50.; Van Horne, *Curios. Miscell.* Dec. 1. an. 3. obs. 129.: Kerkring, *Spic. Anat.* obs. 23.; Littre, *Hist. de l'Acad. des Sciences,* 1701, p. 24.; Mery, l. c. 1712, p. 38.; Fauvel, l. c. 1711, p. 26.; Sue, l. c. 1746; M. Roux, *Mém. sur l'Anencéphalie,* 1825; all quoted by Dr. Brachet, *Recherches Expérimentales sur le Système Ganglionaire.* Paris, 1830, p. 83. sqq. p. 69. sqq., for instances of the absence of the spinal chord.

Also, *Phil. Trans.* 1775.

Brainless fœtuses are not uncommon.

A fœtus attached to another has been minutely described by Dr. Mayer of Berlin, in Graefe's *Journal,* t. x., without brain, spinal chord, or encephalo-spinal nerves. There was one nervous twig accompanying the renal artery, and arising apparently from the renal plexus, which, with the mesenteric, existed and had ganglia.

Imperfect fœtuses have been seen, with some organs evolved, though not even nerves could be discovered. See *Phil. Trans.* 1793. See on this subject the excellent remarks of Dr. Marshall, in his works edited by Mr. Sawrey in 1814, and already quoted.

[a] " A girl lived to the age of eleven years, with the use of her senses, and with voluntary motion, weak it is true, but sufficient for her wants, and even for progression." " After death no cerebellum nor mesocephalon could be found." (Dr. Magendie, *Précis,* t. i. p. 414., and *Journal,* t. xi.) Here was one of Nature's own mutilations, without mechanical injury or disturbance of other parts; and, with patience till it occurred, a multitude of innocent animals would have escaped cruel and disgusting vivisections, and an attempt would not have been made to prove that the cerebellum was necessary to motion or secretion, or to prevent involuntary motions backwards.—The girl had prurigo pudendi, and frequently scratched herself. Some antiphrenologists therefore inferred that she masturbated and showed sexual desires, although she had no cerebellum!

thought to possess nerves. I cannot but believe the blood possessed of vitality; and, if it be not, still a clot of fibrine spontaneously becomes vascular without the aid of nerves, though they may be subsequently produced. Muscles, after the division of the nerves which connect them with the encephalon or spinal chord, contract equally as before, when irritated; nay, if they are over-excited by any means and exhausted, and are then allowed repose, they absolutely recover themselves and obey the stimulus again. In animals liable to torpor, the season of torpidity produces its effects equally upon those muscles whose encephalo-spinal nerves have been divided, and equally if the encephalon and spinal chord, &c. are destroyed. In sleep and even coma, the action of the heart, &c. continues; and, even after the removal or gradual destruction of the encephalon, spinal chord, or encephalo-spinal nerves, the heart still continues to act and the blood to circulate, provided respiration is artificially supported[b], — for respiration depends upon the excitement of the muscles by means of nerves of motion springing from the cervical portion of the spinal chord, and these nerves are excited through the sensation of the want of respiration, conveyed to the chorda oblongata, as Dr. Brachet makes probable, by the pneumonogastric pair, which appears to give sensibility to the pharynx, larynx, œsophagus, stomach, and lungs[c], — parts in all

[b] Duverney, whose experiments on a pigeon in 1673 I mentioned at page 421., also removed the cerebrum from a dog, without a fatal result for some time: the removal of the cerebellum was instantly fatal. Yet, by instituting artificial respiration, he sustained life for an hour after the removal of the cerebellum. In one experiment, the dog "lived twenty-four hours, and his heart beat well." The instantly fatal result of the division of the spinal chord he prevented also by artificial respiration, and found that the motion of the heart continued and the animal could move his body. (*Phil. Trans.* vol. xix.)

Spallanzani removed the brain, without injury to the organic functions. (*Expériences sur la Circulation:* ouvrage traduit de l'Italien, p. 377. Géneve, 1783.) Fontana injured the brain and spinal chord with no more effect. (*Sur le Vénin de la Vipère.* Florence, 1781, t. ii. p. 169.)

Experiments, &c., by A. P. Wilson Philip, M.D., and Wm. Clift, *Philos. Trans.* 1815.

Also, *Experimental Inquiry*, by the former. London, 1826. 3d edit. Dr. Brachet has lately repeated these experiments upon warm and cold blooded animals. (*Rech. Expér.* p. 73. sq.)

And lastly, Fleurens, *Mémoires de l'Acad. des Sc.* t. x. 1830.

[c] Dr. Le Gallois (*Expériences sur le Principe de la Vie*, p. 247. sqq. 1812) first pointed out that a perfectly anencephalous fœtus cannot live after birth,

which sensation is most important. All the organic or nutritive functions proceed: nails grow, wounds heal, vesicatories

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— that respiration will not take place without the portion of the chorda oblongata connected with the pneumono-gastric. The pneumono-gastric are also nerves of motion to the larynx and trachea; and are distributed to the liver, spleen, kidneys, and duodenum, — probably to convey impressions to them from the brain under emotion, and to give them sensibility enough for sensation under causes of great irritation.

The pneumono-gastric on each side gives off, 1. The superior laryngeal, which runs to the membrane of the glottis (see Mr. Swan, *On the Nerves*, plate xvi., Expl. of Plates, p. xlviii.), and therefore gives it sensibility, and to the arytenoid muscles which close it, as well as the crico-thyroid muscle which raises the cricoid cartilage. (Dr. Magendie, *Mém. sur l'Usage de l'Epiglotte dans la Déglutition, &c.*)

2. Twigs to numerous parts in the neck, to the facial, lingual, and three upper cervical nerves, to the cardiac plexuses, the pulmonary plexuses, and the sympathetic nerve.

3. The inferior laryngeal or recurrent nerves (see Mr. Swan, l. c.), which supply "the membrane of the trachea as high as the membrane covering the posterior part of the cricoid cartilage," and the transverse fibres at the back of the trachea, "and ultimately divide into branches which terminate in the lateral crico-arytenoid and thyro-arytenoid muscles," (see papers by Dr. H. Ley, *Lond. Med. Gazette*, June 20. 1835,) besides giving branches of communication with many other nerves. On account of their supplying the membrane of the glottis, Dr. Brachet found that, after removing a portion of the pneumono-gastric nerves from which they spring, a ball of orris-root or a few drops of muriatic or acetic acid might be admitted into the trachea of a dog without uneasiness; whereas, while the nerves were entire, a drop of blood in the trachea induced cough, and the balls and acids most violent cough, which instantly ceased on the division of the nerve, and was succeeded by mucous rattle without expectoration, the mucus no longer exciting sensation, nor the muscles possessing power for its expulsion; and death ensued in less than an hour. (*Rech. Expér.* p 167.) As the recurrents supply the opening muscles of the glottis, the division of those nerves causes the death of young animals, since in them the rima glottidis is narrow; in the older, or in animals whose rima glottidis is of such a form that its sides cannot touch, dyspnœa and a croaking sound of the voice instantly follow from their approximation.*

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* Dr. Le Gallois, *Expériences sur le Principe de la Vie.*

Some think that filaments go from the recurrents to the closing muscles also; but Dr. H. Ley conjectures, with probability, "that these, together with the anastomosing branches of the superior laryngeal and the recurrent, are intended for those rapid and delicate associated actions connected with the voice by which the chordæ vocales are rendered more or less tense, and their vibrating portions longer or shorter; whilst the main branches, described by Mr. Swan as termi-

produce blisters, fractured bones and soft parts unite, in limbs which are perfectly paralysed. But the involuntary functions are closely *connected* with the encephalon and spinal chord; for the *sudden* destruction of these parts, or of a certain extent of them, puts a stop to the circulation.[d] This, however,

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The pneumono-gastric next supply the membrane of the bronchiæ and air-cells, so that, after their division, an animal may be plunged into water without any uneasiness or effort at respiration, although previously violent struggles ensued; or the animal may be kept in confined air or nitrogen, and, although it still breathes and laboriously, it gradually dies, we are told, without any suffering. We breathe from an uneasy sensation; but, after the division of these nerves, the want is little felt. Respiration continues for a time, probably from some nervous connection; for, if the origin of the nerves in the chorda oblongata is destroyed, respiration ceases at once.* Dr. Brachet believes that all excitement of the heart by the brain, even though the cause be pain induced any where, is communicated by the pneumono-gastric; for excitement of the heart from causes of pain ceased on the division of these nerves, and did not occur if they were divided before their application; nor would irritation of the upper extremity of the divided nerve, or of the brain, excite the heart.

They give sensation, we have seen, and also, according to some, motion, to the stomach. According to Dr. Brachet, the stomach still acts but antiperistaltically, so that its muscular excitability does not depend upon the nerve, though it may be acted upon through the nerve. On irritating its œsophageal plexus, the œsophagus and stomach contract, and, after its division, their peristaltic action ceases.†

[d] Dr. Le Gallois, *Sur le Principe de la Vie;* and Dr. Wilson Philip, *Exper. Inquiry.* Probably by excessive stimulus, as the voluntary muscles are afterwards insensible to stimuli, although, after a mere division of their nerves, they retain their excitability.

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nating in the opening muscles of the glottis, are for the purpose of those grosser movements of the rima glottidis connected with respiration and deglutition."

* In considering the continuance of respiration after division of these nerves, and the occasional occurrence of rattling and apparently laborious breathing without any suffering for even a long time before the death of some persons, we must reflect how faint an uneasy sensation causes us almost unconsciously to will an action,—how we wink all day, and hem, without thinking of the sensations which excite our will, or thinking of the exertion of our will. A person may have sensation enough in the lungs to make him breathe, and yet not enough to make him suffer. When dogs plunged in water after the division are said to have made no effort to breathe, I presume that the faint sensation induced them to make a faint effort, but was not sufficient to induce them to contend for respiration, as they must have done, from the absence of air.

† Drs. Tiedemann and Gmelin, *Recherches sur la Digestion.* Drs. Breschet and Edwards, *Arch. Génér. de Médecine,* 1821.

is no more than happens if any important part of the body receives an injury, or if any unimportant part is extensively injured;—if a leg is crushed or falls into gangrene, the whole system suffers, though a leg may be removed and the system be none the worse.[e] The application of stimuli to the encephalon or spinal chord excites the action of the heart, and, even after its removal, of the capillaries: but stimulus to any important part will stimulate others; and even to an unimportant part, if the stimulus is strong. The passions do the same: but they influence all parts; and, though a due excitement of the passions is necessary to the health of all parts, it is only because the body thrives best as a whole when each part fully performs its functions. Compression of the brain causes slowness of the pulse and constipation; but this is only such a sympathetic influence as may exist between any parts. It appears, from Dr. Brachet's experiments, that irritation of the brain affects other parts by means of the pneumono-gastric; for its division prevented all effects of the brain upon the heart.[f]

The removal of a piece of the pneumono-gastric, or the destruction of that part of the chorda oblongata with which it is connected or of a considerable portion of the chorda spinalis, heavily impairs the functions of the lungs and of the stomach[g], putting a stop, some say to the muscular action of the stomach, others to the secretion of gastric juice and to digestion. The

[e] The hearts of six decapitated robbers beat strongly and regularly for nearly half an hour; and after a man's cerebrum and cerebellum were blown off by an explosion of fire-arms, the respiration and circulation continued above half an hour. (Dr. Brachet, l. c., p. 80. sq.)

[f] *Rech. Expér.* p. 118.

[g] Le Gallois, l. c., and many former writers.

Dr. Philip conceives this influence of the brain and spinal chord to be galvanic, as he prevented the ill effects of the removal of a piece of the pneumono-gastric nerve upon the lungs and stomach, by supplying these organs with galvanic influence. (l. c. p. 210. sqq.) Dr. Brachet, however, equally succeeded by mechanically irritating the end of the portion of the divided nerve running to the stomach.

Division of the nerve had no effect if the divided ends lay opposite each other, although a quarter of an inch intervened. (Dr. W. Philip, l. c. p. 226. sqq.)

A mechanical stimulus, or a substance in its nature stimulating, applied to the brain about the origin of the nerves, excites contractions in the voluntary muscles; a substance in its own nature stimulating excites the heart and capillaries, when applied to any part of the brain or spinal chord, but requires to be applied to a considerable portion. (Dr. Philip, l. c.)

animal may continue quietly to eat till the stomach is enormously distended; and this, no doubt, because the stomach is deprived of its sensibility so that its distension is no longer felt, and the animal, though it must at the same time be insensible to the pangs of hunger in it, continues to eat from habit or the pleasure of masticating.[h] We need not suppose its muscular power to be destroyed by the injury of the nervous system, because continued eating must produce over-distension, though the power of contraction be, before the over-distension, unimpaired. Dr. Philip maintains that the injury suppresses the secretion of gastric juice and digestion; but Drs. Leuret and Lassaigne assert that digestion proceeds as before, though even six inches of each nerve be removed in the horse; and Sir B. Brodie and Dr. Magendie found digestion uninfluenced, if the division was made, not in the neck, but close to the stomach; and, again, Dr. Magendie found digestion proceed in brutes after the removal of the cerebrum and cerebellum. (See *suprà*, p. 87.)

The division or ligature of the pneumono-gastric nerve has been a favourite experiment with endless vivisectors from the time of Galen himself; but I believe that Dr. Le Gallois was the first to point out that the blood experiences no longer the chemical changes in the lungs, but their air-cells become filled with frothy mucus, their substance gorged with blood, and their surface marked with dark patches. The engorgement and black patches result, however, merely from the want of changes in the blood; and this partly from the animal scarcely feeling the want of respiration; so that in a rabbit the respirations instantly become very slow, — an instance analogous to the slow breathing of sleep and the much slower of apoplexy, in which states the want of respiration is less perfectly felt; and partly from the stay of all the mucus in the air-cells and tubes, which, like the stomach, have lost their sensibility, so that, the quantity of mucus not being

[h] Dr. Le Gallois found that, after this division, a guinea-pig would eat, from habit or the pleasure of the mouth, till its belly was as long as its body; and the œsophagus would also become distended, sensation being lost and muscular power paralysed. Dr. Brachet kept animals without food, and they showed all the signs of hunger. He divided the pneumono-gastric, and then offered them food. But they were now indifferent to it; and, on being enticed to eat it, they ate on till the stomach would hold no more and the œsophagus was filled. The cessation of muscular action might be the result of merely the loss of sensibility.

felt, none is expectorated, and mucous rattle occurs in the trachea. The blood, consequently, is no longer exposed properly to the air. These changes are declared to happen even after death, if the experiment is made as soon as the animal is killed; but I really doubt this.

Every point of the body communicates with the brain by means of nerves: since, on the one hand, every point of the organisation either is sensible or may by disease acquire sensibility and communicate painful sensation to the brain[i]; and, on the other, mental emotions, continued or violent, may affect any point. We cannot, therefore, be surprised to see nerves pass between the encephalon or spinal chord and parts which ordinarily have no sensation and are never under the influence of volition. Indeed, many parts considered insensible are at all times destined to give some variety of sensation, under certain circumstances, without any morbid sensibility. The want of chemical change in the lungs for less than a minute so impedes the passage of blood through them, that we have an uneasy sensation: the stomach feels hunger, and it, and the intestines, and urinary bladder, feel distension every day in health: the ligaments, undoubtedly, give a peculiar sensation if a joint is over distended: and the testis or coats of the testis when compressed.[k] The functions of the lungs and stomach could not easily proceed without sensation. In the one we feel the want of air, if we interrupt the function, as we continually do when talking and eating and performing many other acts, in all which we are compelled to attend to respiration by an uneasy feeling: without sensation in the stomach, supplies of food would not be given to it and regulated. The necessity for almost continual sensation in the lungs and stomach explains why a nerve goes directly from the brain to these organs,—the pneumono-gastric. The end of the intestines and the bladder require habitual sensation for their functions, and they are well supplied from the spinal chord. The functions of the rest

[i] In nervous disturbance, the parts which carry on the organic functions without sensation sometimes acquire such sensibility that the ordinary silent processes appear attended with sensations: at any rate, unusual sensations are felt in such parts.

[k] I have compressed the tunica vaginalis and the albuginea when the testis was atrophied after mumps, and great pain was felt. Still, although nothing but membranes appeared left, there probably was a portion of the gland, as pressure of the vas deferens is equally painful.

of the intestinal tube, of the liver, kidneys, and absorbents, &c. of the abdomen require no sensation in health ; and sensation, therefore, occurs in them only under unhealthy influences, and they neither require nor have communication with the brain beyond such an amount as all parts possess for occasional sensation and the sympathetic influence of the mental affections of the brain, and that influence which it, like all other organs, exerts at all times on all parts. There is thus a sufficient reason for the presence of encephalo-spinal nerves where there is no volition, and where ordinarily no sensation occurs, without ascribing nutritive or functional influence to them.

Although the division of the spinal chord or of its nerves, or compression or disorganisation of these or of parts of the brain, prevents voluntary power over the corresponding muscles, without suspending the circulation, &c. in them, and does not impede the functions of the lungs or stomach; yet circulation, and, what are dependent upon it, — nutrition and frequently animal heat, — are evidently impaired. Sir Everard Home found that, by dividing the nerves running to the horn of a buck, the temperature of the horn fell about 6° below that of the other, and, as the divided ends advanced in the process of re-union, the temperature rose again towards a level.[l] Palsied limbs are often colder than others, or, as Dr. Abercrombie enounces the fact more accurately, are more easily cooled and heated, — follow variation of external temperature more, — than others. Palsied limbs waste, and the ends of the palsied fingers are very pale, and the nails blue from time to time, for want of use. Division of the trigeminum pair of nerves close to the brain causes inflammation of the eye and cloudiness of the cornea; and its division at its ganglion Gasseri produces opacity of the cornea and ulceration and destruction of the eye.[m] The attempt to cure morbid sensibility of the horse's foot by dividing its nerves has been relinquished on account of the frequent separation of the hoof after the operation. Injury of the lumbar spine frequently occasions alcaline urine. In hectic fever, sweat breaks forth generally as soon as the patient falls asleep, — as soon as the brain becomes inactive. Some persons have large quantities of acid rise into the mouth, and suffer other dyspeptic symptoms, if they fall asleep after dinner. It is indeed maintained that in paralytic parts the muscles only waste, and

[l] *Phil. Trans.* 1826.

[m] Dr. Magendie, *Journal de Physiologie*, t. iv.

their atrophy is ascribed to want of use. The loss of the hoof after division of the nerves is said by Mr. Youat to occur only when considerable inflammation is present at the time; that the horse, having no sensation in the part, knocks it about, and increases the inflammation to such a point, according to him, that the hoof is detached: he assures me that, if no severe inflammation is present at the time of the operation, the hoof is not lost.

Now, such among these effects of division or incapacitation in any way of parts of the nervous system as cannot be attributed to indirect circumstances, do not, in my opinion, militate against the numerous general facts already mentioned of the independence of the organic properties and functions upon the nervous system. I do not see that we are justified in considering these results as more than instances of the sympathetic influence of one part upon another. All parts influence each other and the whole system exclusively of their peculiar functions. The encephalo-spinal nervous system must be like all other parts in this respect: and yet every result of their injury on other parts is strangely regarded as a proof of dependency upon them. Besides its functional powers and influences, its condition, even as to its structure and organic functions, must sympathetically affect other parts, — a fact too often overlooked, and thus power has been presumed for it without reason. When the kidneys are in such a state that they produce sugar, a mental impulse is destroyed, and the power of the genitals is lost. Under diabetes a man usually has no sexual impulse and is impotent, yet no one supposes that the faculty of the brain known as sexual desire, or the vigour of the genitals, depends upon the kidneys. The brain is besides especially connected with every other part of the body, and is one of the most important organs which exist. The effect, therefore, which any injury of it must have over other parts must be very great. But children live and eat and preserve their temperature for many days, though born without brains; and we have seen what was borne by brutes in the experiments of Duverney and his imitators. Nay, we have seen that injury of nerves not supplying a part will injure it; just as the extremities may be absent or removed without injury to the functions at large, and yet diseased states or severe injuries of them may destroy the system. Injury of nerves, just as of any other organs in proportion to their importance, may affect parts, not which they supply, but with which they are connected:

amaurosis and even cataract may follow wounds of the nerves belonging, not to the eye, but to the face; and convulsions may follow wounds of the acoustic nerve. Although disease of the spine injures the renal secretion of urine and causes inflammatory excitement of the mucous membrane of the bladder, disease of the kidney frequently produces such an affection of the corresponding part of the spinal chord, and consequent paraplegia [n], that both are ascribable to sympathy only; for no person would consider the spinal chord as depending on the kidney for its power. Castration prevents the horns of the buck from coming, or from growing longer and being shed; and the removal of the boar's tusks destroys his violent sexual propensity [o]: yet these effects are not thought to show dependence, but merely connection.

Although the involuntary and unconscious functions do not appear to depend upon the encephalo-spinal system, an argument in favour of their dependence upon the ganglions and ganglionic nerves, properly so called, is the fact,—that the ganglionic system of nerves is formed before the encephalon and spinal chord; indeed, the nervous system of the chest and abdomen are fully formed, while the brain appears still a pulpy mass. [p] These ganglia and nerves, it may be urged, would hardly be formed before the encephalon and spinal chord but for the sake of the organs which they supply, and the functions of which (with the exception of the genitals) are as perfect at birth as at adult age; while the brain and its mental powers are slowly perfected. Although the encephalon and spinal chord may be absent in monsters [q], the ganglionic system is, perhaps, always perfect, unless in extreme deviation, where the nervous system may be diffused invisibly, as in some lower animals. But I do not know

[n] See a paper by Mr. Stanly, full of interesting facts, in the *Med. Chir. Trans.* vol. xviii.

[o] Lisle *On Husbandry*, quoted by the Rev. Gilb. White, *Nat. Hist. and Antiq. of Selborne*, 1837. p. 304. sq.

[p] Gall, l. c. 8vo. t. i. p. 191. See also 4to. vol. iii. p. 239. sq.

[q] Lobstein, p. 52. sqq. *De Nervo Sympathetico*, 1823, relates six cases of absent brain and other organs, where the ganglionic system was perfect or even remarkably large; and Dr. Cayre relates the dissection of nine idiots, in whom the encephalo-spinal system was diseased and wasted, the ganglionic healthy. *Nouveau Journ. de Méd.* t. iv. In Gall's 4to edit. vol. i. p. 37. sqq. will be found a history of the hypotheses respecting the use of the ganglia, as well as in Lobstein's more recent work.

that it has ever been absent. The heart never exists without its ganglion; so that the cardiac ganglion, as the heart is the first organ that comes into action, is the commencement of the nervous system.

A striking difference is observed in the structure of ganglionic nerves and the effect of injuries upon them. Bichat asks, "What anatomist has not been struck with the difference between the cerebral and ganglionic nerves? Those of the brain are larger, more numerous, whiter, denser, subject to fewer variations. On the other hand, extreme tenuity, considerable number, especially at the plexuses, a grey colour, remarkable softness, and very frequent varieties, are the characters of the ganglionic nerves, if you except those which communicate with the cerebral, and some of those which unite" the ganglia.[r]

If these nerves are cut, or their ganglia torn, some assert that no pain is produced. Dr. Brachet declares that he found the spinal nerves running to the sympathetic ganglia to be very sensible: the nerves running from and between ganglia to be insensible, unless inflamed, and, when inflamed, to become sensible, but at the inflamed point only, and to lose their sensibility again if the twigs of communication with the spine were divided: a ganglion to be sensible or insensible accordingly as a point in it was touched or not in which a spinal nerve ran, and to lose all sensibility on the division of the nerve connecting it with the spine; to be very sensible if inflamed, but insensible again on the division of the spinal nerve.[s] If all the ganglia of the neck are removed, and even the first thoracic, Dr. Magendie says that no sensible or immediate derangement of the functions is observable, even in parts to which the filaments united with them may be traced.[t] Bichat long since remarked no disturbance of the heart's motion on attempting to irritate, or on dividing, the cardiac filaments of the sympathetic; nor of the stomach, bladder, &c. by applying violence or stimuli to their ganglionic nerves. Neither did he succeed with galvanism[u]: but Humboldt and Dr. Fowler, Home and

[r] *Recherches Physiologiques*, p. 72. sq. 1805. See also *Anat. Générale*, t. i. p. 222.

See also Gall, l. c. 4to. vol. i. p. 40. sqq., 8vo. t. vi. p. 312.

Dr. Magendie, *Précis Elément.* t. i. p. 171. sq.

[s] l. c. p. 304. sqq.

[t] Dr. Magendie, l. c., says he has made these experiments repeatedly.

[u] l. c. 334. sqq., 360. sqq.

Weinhold, say that they succeeded with galvanism in the case of the heart[x]; and Dr. Bartels declares that, when he opened the chest of six robbers in 1826, immediately after decapitation near Marbourg, he found the heart beat regularly for half an hour, and, when languishing, to be momentarily excited by irritating the great sympathetic, though irritation of the spinal chord had no effect on it, but on the muscles of the trunk.[y] Dr. Brachet asserts that, on dividing the cardiac plexus, the action of the heart instantly ceased for ever; probably, however, from the shock, since the hearts of brutes taken out of the body will beat.

But let us examine this hypothesis a little farther. Besides the mental faculties of the encephalon, and the transmission of the will from it, and of impressions for sensation to it, by the spinal chord and the nerves of motion and of sense, two other kinds of phenomena remain, one of which possibly, and the other certainly, depends upon the nervous system. The former is the excitability, irritability, vitality, life, or whatever else it is termed, possessed by every part: the other is the various degrees and kinds of sympathy which exist among the different parts of the system, and the influence of the mental feelings upon the body at large, the susceptibility of which influence is but that of sympathy with the encephalon. Now the ganglions and ganglionic nerves must have some function, and, as they are not the organs of the mind, nor concerned in sensation, or volition, the only functions which remain are the supply of excitability, the transmission of sympathy, and the effects of mental emotions, and the affording a passage to encephalo-spinal filaments of sensation to those parts which do not otherwise receive any; for every part is capable of sensation in inflammation, and therefore must always have nerves connecting it with the brain, however indirectly. The rise and progress of the opinion which gives them the first office are detailed by Dr. Fletcher, who advocates it strongly, and, in addition to the fact of the earlier development of the ganglionic than of the encephalo-spinal system, urges the following arguments.[z]—It is more strongly developed in children and females than in the less irritable adult and male. They appear universally distributed. The arteries of the brain and all the

[x] Dr. Le Gallois, *Expériences sur la Vie*. Dr. Brachet, l. c. p. 127.

[y] Dr. Hufeland's *Journal*, quoted by Dr. Brachet.

[z] See Dr. Fletcher's *Rudiments of Physiology*. Edinb. 1836. P. ii. a. p. 64. sqq.

larger blood-vessels are supplied by them, and these may convey them throughout the frame. There is no reason to say that the ganglionic nerves merely arise from the encephalo-spinal: they give branches evidently to the encephalo-spinal [a], and consequently we may presume that they are as extensively distributed; and the ganglionic nerves are very fine and at length must be invisible. The property they give must be supposed similar to that of sensibility: and we see, therefore, why they have ganglia exactly like those of nerves of sensation, inasmuch as they consist of grey and white substance inextricably mixed, and their white matter is exceedingly soft like those nerves, whereas in nerves of motion it is hard; and we are not surprised to find them convey galvanism badly, like nerves of sense, while nerves of volition conduct it well; nor to find that, as narcotics applied to nerves of sensation destroy the sensibility of the parts which these supply, so, when applied to ganglionic nerves, narcotics destroy the excitability of the parts supplied by them. The filaments of ganglia are declared by Lobstein [b] to be different according to the organs which they supply, just as we know the vital properties or excitability of every organ to differ. Hence we cannot wonder at the continuance of the organic functions during inactive states of the encephalo-spinal system,—in sleep and coma; nor even when the brain is removed, or the muscle itself is detached from the body: we cannot wonder at the division of the principal trunks belonging to a muscle not preventing its irritability from being renewed after exhausting stimulation has been intermitted. Lastly, when the encephalon, or both it and the spinal chord, are wanting in monsters, the ganglionic system almost always, if not always, exists; and is said never to be absent, if a monster is not far

[a] This is shown by Mr. Mayo, l. c. p. 265.; and Mr. Swan conceives that there is no doubt of the branches of the sympathetic proceeding to the sixth, instead of arising from it. (*On the Nerves.*) But, above a century ago, Petit demonstrated the error of those who derived the sympathetic from the fifth and sixth pairs (*Mém. de l'Acad. Roy. des Sc.* 1727); and Fontana, according to Girardi, argued against the origin of the sympathetic from the third or fifth pair, because the twigs were not detached from these pairs, but ran to them; so that they should be called the end and not the origin of the sympathetic. Professor Panizza declares that the branches of the sympathetic which ascend with the carotid artery merely entwine around the sixth pair, and may be detached without injury to their continuity. (*Ricerche Sperimentali*, p. 6.)

[b] *De Nervo Sympathetico.* 1835.

removed from the human form: and in idiots, with a want of quantity and quality of encephalo-spinal substance, the ganglionic system is usually well developed and sound. No wonder, therefore, that, by irritating these nerves, the parts to which they run are not pained or moved; for they are not nerves of sense or motion, but, instead of stimulating, give the property of being capable of stimulation. Again, the division of the ganglionic nerves is not followed by a loss of excitability, as the nerves in the parts themselves appear calculated to produce excitability, since the ganglionic nerves contain, like their ganglia, grey and white substance, not white substance only, like the nerves of sensation and the nerves of motion, both which are merely transmitters, and not producers, of the respective qualities with which they are concerned.

A powerful argument against this hypothesis is the circumstance of no nerves existing in vegetables, although they are nourished and secrete great varieties of substances, — perform organic functions similar to those of animals. Another is the account of fœtuses having existed without nerves; imperfect fœtuses indeed, but still animal organised active substances.[c] Another is the circumstance of a clot of blood becoming organised before it is connected with surrounding nerves or vessels. Another is the fact that, while some parts are abundantly supplied with ganglia and their nerves, other parts of great size, of great vital properties, of great secretion, have no more supply than is communicated along all arteries, and which is very far short of what parts supplied with ganglia and plexuses must possess. I allude to the extremities, in which are a great extent of superficial and cellular secreting structure, as well as the synovial membranes of the joints, great masses of muscle, &c. that would require ganglia for their nourishment and powers as much as the stomach, liver, and other viscera; and yet they have no ganglia and receive no more ganglionic nerves than what pass insensibly along the arterial coats, while the viscera have copious supplies to their blood-vessels, amidst which numerous plexuses and ganglia are found. The various experiments made to prove the importance of nerves to secretion are considered unsatisfactory by Dr. Brachet — a great supporter of the necessity of the nerves to all the organic functions; and his own appear to me equally unsatisfactory. Finding that he could

[c] Dr. John Clark, *Phil. Trans.* 1775.

not prevent the secretion of urine by dividing all the nerves of the kidney, he divided the renal artery, and passed a canula between the two portions, so that no nerves could run to the organ along the arterial coats. Secretion ceased. But the functions of the small vessels were unlikely to continue when the trunk was so severely injured: just as we shall find the functions of the ovaria or of the testis often to be arrested by dividing the Fallopian tube or vas deferens. For what purpose of nutrition or supply of properties can a ganglion be particularly required just in the situation of the ophthalmic or the otic? But, if we reflect that the motions of the iris and muscles of the internal ear must be regulated by the condition of certain other parts, we can understand why those ganglia exist in their respective places. For the ganglionic system, no doubt, communicates important influences. The functions of each of the complicated and numerous organs of all but the lowest animals, require constantly to vary according to the condition of others. Not only, for instance, does every organ of digestion, assimilation, and excretion, require to be in nice adjustment with another and with all, but is each affected by organs not forming a part of the group nor necessary to their powers. The nutritive functions do not require the brain; yet if the brain is harassed by a disagreeable state of feeling — sorrow, vexation, anxiety, &c. — whatever be its intensity, that group suffers, and dyspepsia, diarrhœa or costiveness, pale or morbidly coloured stools, a morbid colour of the urine and the skin, in some degree or other result. Whereas, in a happier state of mind, the functions, cæteris paribus, go on well; and, in a truly happy state, persons are often struck with the excellence of their condition. *The converse operation of all these upon the brain is as certain.* Now, if such is the mutual influence of organs not necessary, except indirectly, to each other, but bound up, where they all exist, into a common whole, so that the well-being of each is essential to the well-being of the whole, we may well conceive the important influence of organs upon each other which co-operate in function. I conceive the influence of organs upon each other to be incessant, and to be ever varying accordingly as the state of each influencing organ varies: and that they are all at all times influenced and influencing. This constant mutual influence is indispensable to perfect function, though it frequently disturbs function: and, as all seem thus bound together into a common whole, the removal of this general and particular influ-

ence by the division of the nerves of an organ must affect it; and the more readily shall we believe this, when we consider that the nerves are so minutely and universally distributed throughout each organ. But the dependence of all parts for their vital properties upon nerves is a very different matter, and appears to me far from having been proved or even rendered probable. If the vitality or irritability, &c. of all parts is given by the nerves, what gives it to the nerves? If one mass of matter can become by combination and organisation and suitable circumstances endowed directly with it, why cannot another? To suppose nerves indispensable to vitality is to ascribe to nature circuitous and complicated means when unnecessary. The action of voluntary nerves is merely to excite the irritable muscular fibre; the operation of nerves of sensation is not to endow the constituent parts of organs with sensibility, but to be present in the organs, and with their sensibility feel impressions made upon them. But this hypothesis does not make the nerves excite, as in the former case, nor be the residence of the peculiar properties of the part, as in the latter. It makes the nerves give powers of contraction, secretion, &c. none of which they themselves possess. When persons suppose vitality to be given by nerves, they do not suppose the nerves to be the organ, but to communicate to the constituent parts properties which they themselves or their system have engendered, and which properties they themselves do not possess, except that they have vitality in common with all parts. If all organs were nerves, I could understand how nerves might be declared necessary to all parts for their vitality: but, as nerves are not supposed to perform the functions of the organ, I cannot see why the organ should not by its composition and organisation be sufficient, without another composition and organisation to give it the powers it possesses: and besides, there are the facts respecting vegetables, nerveless fœtuses, and clots of blood, already mentioned, which show that vital properties may exist without nerves. The various specific properties of the various parts of the system are totally different from those of the encephalon, spinal chord, ganglia, and nerves, and must depend upon the specific composition and organisation of each part, or each part would not require and have a specific composition and organisation. If a part runs to another and pervades this, as in the case of the nerves of sensation, that part, having its own properties wheresoever it goes, will have them in the part

which it pervades; but it cannot give them to this, and far less can I believe that it gives to this properties which it itself does not possess: and, as to its performing the offices of the part which it pervades, the thought is not entertained; and yet, except by admitting such an absurdity, I cannot see how the power of secretion, nutrition, &c. can be ascribed to nerves. The hypothesis is usually confined to the ganglionic system: and the encephalon, spinal chord, and encephalo-spinal nerves are considered to be appropriated to the intellectual and moral functions, sensation, volition, and the mutual influence of the brain and rest of the body. That the ganglia and ganglionic nerves are developed in proportion to the activity and force of the circulation, and to the development and activity of the functions of organs, is no more an argument for the dependence of the vital properties of these upon them, than the simultaneous development of the ganglia and of the various viscera in early life. The sooner the viscera are formed, the sooner must the ganglia and nerves which convey influence to and from each of them be also formed; and, the more bulky and active an organ, the more nerves will it require to influence and be influenced by other organs. All must allow that the ganglia and ganglionic nerves cannot be for the purpose of vitality alone, since branches from both anterior and posterior encephalo-spinal nerves join them and form part of them.

I should consider the functions of all nerves to be analogous to each other. The spinal chord and encephalo-spinal nerves do not give properties; they communicate only between the brain and the rest of the body. They convey to the brain an impression of the state in the form of sensation; and they convey an influence from the brain in the way of emotion or volition. They do not bestow the qualities of the brain, much less convey qualities which it has not. They convey volition, and the influences of the moral feelings, from the brain, and carry back the impressions of sensation to the brain. Analogy would incline us to suppose that nerves running between other parts would convey to those parts, in either direction, the impressions of the state of the communicating parts, —this impression, like the impressions of sensation when followed by volition, being sometimes followed by an influence to some third organ or some other portion of the first organ.

Dr. Brachet concludes from his experiments that the encephalic nerve, called pneumono-gastric, gives moving power to the air-

cells of the lungs, the stomach, and the upper part of the small intestines: and that the motion of the lower part of the small intestines, of the large intestines, the bladder, and uterus, is dependent upon the spinal chord. That the action of the bladder and the lower part of the large intestine depends upon the spinal chord cannot be doubted; because the functions of the bladder and rectum are carried on with sensation and volition. If these parts are paralysed, the rest of the large intestines and the adjoining portion of the small will suffer accumulation, from which he drew his inference, though they themselves be not paralysed. The regular contraction of the stomach ceased indeed after the division of the pneumono-gastric; but the stomach was not paralysed, for it acted antiperistaltically after the division. This he ascribes to irritation of the divided end of the nerve. But such an irritation ought as readily to have excited the regular contraction of the stomach. Dr. Wilson Philip denies that the division paralyses the muscular coat of the stomach; and Drs. Leuret and Lassaigne say the paralysis is confined to the cardia. If Dr. Brachet is right in his fact, still some might say it was through the division of the ganglionic nerves united with the pneumono-gastric that the paralysis was occasioned. The instant cessation of the motion of the heart on the removal of the cardiac ganglion may be ascribed, I have already said, to the shock as probably as to the absence of the ganglion.[d]

[d] I will not presume to doubt Dr. Brachet's fidelity, but his results all square so wonderfully, except where he is not aware they do not, that confirmation would be desirable, were it not for the torture necessary. Some points, however, in his experiments I do not comprehend. In one experiment (lxxxiv.) we saw that, after the division of the pneumono-gastric, a puppy might have its head plunged in water without making any effort to raise it and to breathe; yet in other instances (xl. and xli.) puppies made violent efforts to inspire. He does not explain the difference, but explains the efforts to breathe on the score of habit. The explanation I attempted of the difference (*suprà*, p. 434.) may not be satisfactory to all. When wishing to show that the secretion and discharge of semen are independent of the encephalo-spinal nerves, he mentions the case of a man completely paraplegic, and as high as all the lower fourth of the abdomen, without any sensibility of the external parts, or the interior of the rectum or urethra: and yet the man had two children in the time. How the necessary movements were performed, without voluntary power of the lower parts, and how ejaculation could occur without sensation of the external parts or urethra, I cannot imagine. He reduced poor tom cat to the same situation by dividing the spine in the lumbar region. Here he allow hat the necessary movements were impossible. However, he sup-

When I consider that every part must have nerves for feeling, because every part may become sensible — capable of experiencing

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plied their place by "une sorte de masturbation," which was neither more nor less, I suppose, than *la masturbation.* It required more time, he says, but at length he made the cat emit. This was what some bluff John Bulls would call French taste. Now, as the cat had lost all sensation, I cannot see how it could be alive to the pleasures of masturbation, — how emission, which in coition results only when sensation arrives at a certain height, could be excited; nor how the presence of semen in the urethra could be felt and ejaculation effected. Whatever might have been the effect of imagination on the man, the cat must have been a stranger to the pleasures of imagination as much as of Dr. Brachet's masturbation. Dr. Brachet, on the other hand, seemed delighted; for, as if he had not proved what he wished, he masturbated the cat again the next day (je fis répéter la même manœuvre (literally), et une nouvelle éjaculation eut lieu); and, not yet satisfied, he did it again the day after. There, I am thankful to say, he stopped. "Je m'en tins là, et l'animal me servit pour d'autres expériences." Not only were these repetitions superfluous, but the experiment was altogether superfluous, as the man's case was perfectly similar. I do not think a physiologist would have ventured to divulge such a disgusting experiment in this country; and I cannot refrain from expressing my horror at the amount of torture which Dr. Brachet inflicted upon so many unoffending brutes. Nearly or quite two hundred must have suffered under his hands. I hardly think that knowledge is worth having at such a purchase; or that it was ordained that we should obtain knowledge by cruelty. I care nothing for killing a brute outright, without pain: it is then but as before it was born, feels no loss, and escapes all further chance of suffering. Vivisection may be justifiable in some instances. But before an inquirer commences an experiment of torture, he ought to be satisfied of its absolute necessity, — that the investigation is important and the means indispensable; and also that he is master of the existing knowledge on the subject, and qualified to operate and to philosophise upon the results. He should proceed to the task with the deepest feelings of regret. I do not wish to make a parade of feeling: but to torture animals unnecessarily is a most cowardly and cold-blooded act, and in my opinion one of the utmost depravity and sin. A course of experimental physiology, in which brutes are agonised to exhibit facts already established, is a disgrace to the country which permits it. My esteemed French friends will pardon me, but I fear that in France there is among many too little repugnance to vivisection *: and I am sure that the following experiment would have caused Dr. Brachet to be blackballed in any respectable

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* In his youthful days the tone of feeling among French medical students must have been bad, unless the following brutality was followed by immediate expulsion from the hospital. He says that one of his colleagues, when he was interne of the Hôtel Dieu, regaled the rest of them with a dinner of cats, *which he had experimented upon in their lifetime;* and the next day sent the skins, bowels, &c. to the party in order to let them know what they had eaten. (p. 338.)

impressions and transmitting them for sensation to the brain, and must have nerves for incessantly influencing and being influenced by the rest of the frame, and in many instances for influencing or being influenced by some other organ in particular, the existence and the amount of nerves called the ganglionic system, in addition to those which convey volition and possess sensibility, is explicable; and I conceive it unnecessary to invent any other use of them. These purposes of the ganglionic nerves are certain. To ascribe others is an hypothesis; and in my opinion a very improbable and inconsistent hypothesis. The old name of sympathetic system appears to me highly proper, because it expresses the use of the system, as far as is known to us. The especial use of ganglia is unknown. If Gall's opinion of the use of the pulpy substance is right, and I think it is, they, as they contain pulpy substance, may be, like ganglia in the brain and chord, destined for the origin and reinforcement of the nerves, as well as for their mingling. The encephalo-spinal nerves originate in pulpy substance; and the ganglia of the spinal nerves of sensation are probably to give them the greater bulk and num-

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society in England, for a physiologist was blackballed at the Royal Society from the horror excited by an account read just before of experiments in which rabbits' heads were crushed, though, on reflection, it was found that these experiments were unattended with pain, and he was honourably elected on an early occasion.—Expt. clxi. "I inspired," says Dr. Brachet, "a dog with the greatest aversion for me by plaguing and inflicting some pain or other upon it, as often as I saw it. When this feeling was carried to its height, so that the animal became furious as soon as it saw or heard me, I put out its eyes: I could then appear before it, without its manifesting any aversion. I spoke, and immediately its barkings and furious movements proved the passion which animated it. I destroyed the drum of its ears, and disorganised the internal ear as much as I could: when an intense inflammation which was excited had rendered him deaf, I filled up its ears with wax. He could no longer hear at all. Then I went to its side, spoke aloud, and even caressed it, without its falling into a rage,—it seemed even sensible to my caresses." Nay, Dr. Brachet repeated the same experiment on another dog, and begs to assure us that the result was the same. And what was all this to prove? Simply, that if one brute has an aversion to another, it does not feel or show that aversion when it has no means of knowing that the other brute is present. If he had stood near the dog on the other side of a wall, he might equally have proved what common sense required not to be proved. After all, I do not understand how it happened that the poor dog did not scent him. I blush for human nature at detailing this experiment; and shall finish by informing my readers that the Memoir containing this, and all the other horrors, obtained the physiological prize from the French Institute in 1826.

bers which they have above those of motion. The ganglionic nerves establish a communication between all parts without particular reference to the encephalo-spinal mass, and therefore do not originate in it: they would seem to require origin in pulpy substance somewhere, and therefore I should have imagined *à priori* that masses of pulpy substance would exist here and there for the origin and reinforcement of the nerves of general organic communication. Of course the ganglia must contain fibrous matter also; and, while they may serve for origin, or reinforcement, they appear to serve for mingling the filaments which enter and leave them. It is also possible that the ganglia are analogous to the encephalon and spinal chord, — that they act like certain portions of the encephalon and spinal chord in this, that, as soon as an impression is conveyed to them from one part, they may send forth an influence; just as, in the case of the encephalo-spinal mass, a sensation is felt and a muscular action may ensue.

We see encephalo-spinal nerves run to these ganglia, and some run in great abundance to parts not voluntary. They apparently mingle in ganglia with all the other filaments in the ganglia, as much as these do together; but they are not imagined to convey life, or the power of nutrition, secretion, &c. Why then should the others? They appear, like those which do not run to the ganglia, to convey impressions of sensation to the brain and of emotion or will from it: as well as such mutual influence as exists among all parts. Both the posterior and anterior root of the spinal nerves run to the ganglia of the sympathetic, as Scarpa showed above fifty years ago [e], and Sömmerring [f], whose remarks are now confirmed by Panizza.[g]

When sensibility is constantly wanted, as in the case of the lungs and stomach, and of the pelvic intestinal and urinary organs, a large supply of encephalic or spinal nerves is seen, and is given directly, without the intervention of ganglia:—the pneumono-gastric nerves, besides forming abundant communications with ganglionic nerves, run directly to the lungs and stomach, and certain sacral nerves to the rectum and pelvic urinary organs. The evident purpose of the encephalo-spinal nerves which run to ganglia being to convey impressions in both directions, I shall not

[e] *Anat. Annot.* lib. 1. § xi. p. 18.

[f] *De c. h. fabrica,* t. iv. § clviii.

[g] *Recerche Sperimentale.* Pavia, 1834. &c.

ascribe other purposes to them any more than to those nerves of the same class that do not run to ganglia. They take this course probably for convenience and complete mingling; just as the spinal nerves of sense and motion run together in one trunk, and these mingle by means of plexuses.

I may remark that it is even requisite not only for different organs but for different structures in the same organ to sympathise: a stimulus applied to the inner surface of the alimentary canal, heart, or urinary bladder, causes the muscular fibres to contract.

This mutual influence is *sympathy;* and it exists universally throughout the system, although the more palpable and striking instances of it only pass usually under that name.

We will now consider sympathy more minutely.

By sympathy[h] is meant the affection of one part of the body directly by the affection of another, through vital agency alone, independently of physical. When the sun shines into our eyes, or something irritates the nostrils, the expiratory muscles contract violently and we sneeze by sympathy. If the fauces are tickled, we vomit by sympathy. If cold is suddenly applied to the surface, the bladder endeavours to expel its contents by sympathy. This property of sympathising is indispensable to the functions of the body. Unless the operation of one part is varied according to the condition of another, the harmony of our functions would be destroyed. When the uterus has been gravid its full time, the breasts secrete milk: perhaps before this period, or whenever it may expel its burden. The presence of food in the mouth produces a flow of saliva from all the salivary ducts; and when semen touches the inner surface of the urethra the levatores ani and ejaculatores seminis are thrown into convulsions. When the skin perspires but little, the kidneys secrete more urine. The extreme importance of sympathy will appear when we consider that it occurs not only between different organs, but different parts of the same organ. The blood, the chyme, the fæces, are not applied to the muscular portions of the vascular and alimentary systems, but to their lining membrane;

[h] " J. H. Rahn, *De causis physicis Sympathiæ,* Exerc. i.—vii. Tigur. from 1786. 4to. *Sylloge select. eorum opuscul. de mirabili sympathia quæ partes inter diversas c. h. intercedit.* Edited by J. C. Tr. Schlegel, Lips. 1787. 8vo."

yet the irritation of this, independently of distension, excites the action of the muscular tissue. In disease these sympathies are sometimes more striking; because there may be an undue excitement of the part influencing, or undue excitability of the part influenced. An exquisitely sensible growth at the end of the rectum may produce tenesmus of the expelling muscles. On the other hand, in morbid excitability of the intestines, although the stomach be perfectly healthy, the ingurgitation of warm fluid into it will often cause immediate defecation; in neuralgia, at a distance from the stomach, oppositely, I have seen an instant aggravation of pain when any thing was swallowed; and I have attended two cases of violent cough in young men from the slightest touch of one half of the chest [i], though this was not in the least tender; indeed we have the skin exquisitely tender in some cases of hysteria, and when it is inflamed, without such effect. Sometimes natural sympathy may languish from the want of excitement in the influencing part or of excitability in the influenced. The iris will not contract by light if the retina becomes insensible; and, on the other hand, if the nerves of the iris are paralysed, the stimulation of the retina by light will fail to excite the iris to contraction.

Sympathies occur in disease between parts which are not observed to sympathise at all in health; and the disease may be in the affecting or affected part. When the liver is inflamed, the right shoulder often aches; when the hip joint is diseased, the knee is often the seat of severe pain: on the other hand, pain in an extremity often increases the very instant that stimulating articles are swallowed which in health scarcely caused a glow even in the stomach, and which still do no more than this in the stomach while they aggravate the pain. In disease new sympathies occur between parts which naturally sympathise, as when constipation of the intestines produces vomiting; and the breasts

[i] I presume that, as the sensibility of both halves of the surface was the same, the reason of such effects from touching the one only was, that the morbid excitability existed in that half only of the expiratory part of the spinal chord with which the nerves of sensation of that side were connected, and with which the expiratory portion of the other side sympathised. In hydrophobia, a slight blast of air, or the settling of a fly upon the surface, causes the inspiratory muscles to act suddenly and violently, though the skin is not tender to the touch. Yet I will not adduce this to illustrate the second cause of morbid sympathy, because a strong flash of light has the same effect; and light, noise, and the application of cold to the surface, or any slight and sudden cause of sensation, are very unpleasant, and show a morbid sensibility of all the external senses.

may become painful, and even secrete milk, when the uterus or the ovaria are only diseased.

The influence of mental emotions is an example of sympathy. The affection of the nutritive functions of the brain — such affections as are common to it and all other organs — the state of its circulation, the degree of its general excitement and of its strength, the state of its structure, all may sympathetically influence other parts, and may be influenced sympathetically in turn. But, besides these, the condition of the peculiar functions of certain parts of the brain exercises very powerful influence upon every part of the body. When grief, fear, anxiety, despair, terror, or contentment, hope, enthusiasm, joy, love or hatred, sexual passion, &c. &c. — occur in the brain, certain sympathetic effects take place in certain other parts of the body, as in the circulating organs at large, in the genitals, &c.; and the effect may be violent, even to destruction of life and perhaps laceration of structure, or continued so as, if agreeable, to remove disease, or, if unpleasant, to occasion functional or structural derangement in any part that may be the most predisposed. Now blushing under anger or shame, paleness, polyuria, and diarrhœa, under fear, erections under desire, all called effects of the passions, can be but so many changes occurring sympathetically from certain states of certain parts of the brain, as peculiar states of other functions of other organs affect different organs sympathetically.

It must be obvious that the sympathising part is not always that which appears to sympathise. When a voluntary muscle contracts sympathetically, it is not the muscle but the nerves moving the muscles, and indeed generally the ultimate fibres in the encephalon or chord, that are sympathetically excited; and the contraction of the muscle is the result of their excitement, just as it would be if their excitement occurred in any other way. The sympathy is not between the excited part and the muscles, but between it and the nerves of the muscles: wherefore, if the nerves of the muscle are divided, the sympathy still exists, but ceases to be manifest, because the muscles are no longer influenced by the sympathising nerves. Hence Bichat [k], — who divided sympathy

[k] *Anatomie Générale,* t. i. p. 183. sq.

John Hunter divides sympathy into general and partial; such as pyrexia from a wound, and vomiting from irritation of the fauces. Partial sympathy he subdivides into remote, contiguous, and continuous, — Where there is no evident connection between the sympathising parts sufficient to account for the circum-

as it affects animal contractility or sensibility, tetanus from a wound in the extremities being an instance of the former and pain of the knee in hip disease an instance of the latter; and as it affects organic contractility or sensibility, of which palpitation from disorder of the stomach is an example,— states that sympathy of animal contractility occurs only when the nerves connecting the affected muscles with the encephalon or spinal chord are entire. When he divided them, the convulsions in the corresponding muscles ceased: and the iris ceases to contract when the third pair is divided, though light glares on the retina.

Neither, where sympathetic muscular action arises from a sensation, will it occur, if the nerves communicating impressions from the affected part to the sensible part of the nervous centre are compressed or divided, or if the brain itself is unable to receive the impression. If the optic nerve is divided, the sun's rays will not excite contraction of the iris. Although the stomach in an animal newly dead may be thrown into contraction by mechanical irritation, no sympathetic action of the diaphragm and abdominal muscles,— no vomiting, occurs [l]; in perfect coma neither sneezing nor contraction of the iris can be induced by applying stimulants to the nostrils or letting the sun's rays into the eye.

The sympathies of the organic functions are not all ascribable, as many might imagine, to continuity of surface; for, after dividing the œsophagus of a dog, Bichat produced vomiting equally as before, on irritating the fauces [m], and Dr. Brachet sneezing on irritating the nasal membrane after having divided the trachea.[n]

Sympathy depends on the peculiarity of the impression as well as upon the part. "When the sides or soles of the feet are tickled," says Dr. Whytt, "the body is often thrown into convulsive motions; but nothing of this kind happens when those parts are either inflamed or wounded: neither an acrid injection of a solution of corrosive sublimate, nor the introduction of a catheter into the urethra, occasions any alternate convulsive motions of the

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stance; as vomiting from the pregnant state: — Where there is proximity of the sympathising parts; as tenesmus when a stone exists in the urinary bladder; — and Where, as most commonly, the sympathising parts are continuous; as itching of the nose and verge of the anus from worms in the intestine. *Treatise on the Blood, &c.* Introduction.

[l] Dr. Whytt, *On the Vital and Involuntary Motions.*

[m] *Anat. Générale,* t. i. p. 192. [n] l. c. p. 298.

acceleratores urinæ, although the semen, which stimulates the nerves of the urethra much more gently, has this effect."

The same cause, too, may produce the same sympathetic effect, though applied to different parts. Convulsions arise from tickling any part of the skin capable of the sensation of tickling; nausea from a disgusting smell, taste, or sight: for the sympathetic effect results from the peculiarity of the impressions in the nervous centre.

The same sympathetic effect, lastly, may arise from many different causes in different parts: vomiting may arise from injuries of the head, a stone in the kidney, pregnancy, disgust, sailing, &c.[o]

Now, although it is evident that nerves are necessary to sympathetic contractions of muscles which are never moved but by the stimulus of nerves, viz. the voluntary, because it is the roots of these nerves in the brain or chord that sympathise, and the chords convey the sympathetic excitement; and that nerves are necessary to convey those impressions which occur in any parts and must be transmitted to the encephalon or spinal chord in order that the roots of nerves in these may be excited to stimulate the voluntary muscles ultimately affected; and although we must conceive that the influence of the passions must be transmitted to the various sympathising parts by means of nerves: still some deny that other examples of sympathy arise from nervous connection, because it frequently happens that no particular nervous communications of sympathising parts are discoverable, as between the nose or eye and diaphragm, although sneezing follows from a pinch of snuff in the nose or the sun's glare upon the eyes, while remarkable connections exist between other parts not particularly disposed to sympathise.[p] Vegetables, it is urged, which are not known to have nerves, show what has been termed sympathy: if a leaflet of the sensitive plant is stimulated by a burning-glass the whole leaf contracts and the foot-stalk drops; when the branches of trees feel the warmth of summer, the sap ascends from the roots, and even in a frost it will ascend from the roots through the stem, if a single branch is introduced into a hothouse.[q] But the former phenomenon is probably the result

[o] See Dr. Alison, l. c.

[p] Consult Dr. Whytt, *Observations on Nervous Diseases*, ch. i.

[q] Sir Gilbert Blane, *Medical Logic*, 3d edit. p. 154. In the *Times* for

of mere continuity of surface, which sort of extension of effect occurs in animals; and the sap is thought to rise from the roots in consequence of the mere expansion of the branches: but all true sympathy is no doubt effected by nerves, though mere nervous connection without peculiar disposition, or property, will not explain it.

The smaller number of organs and the continuity of most parts of vegetables produce sufficient connection of all spots without the necessity for distinct intervening bodies like nerves, which are absolutely required to connect the numerous, separate, and frequently quite uncontinuous and very distinct, organs of complicated animals.

Although the sympathies of animal systems, not explicable by continuity of surface, but true sympathies, must, I conceive, depend upon *nervous* communication, even where the sympathising part is not naturally stimulated by volition nor known to be stimulated to its functions by any thing but its contents, and although nervous communication can always be shown; still the intervention

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October 23. 1834, when I read it daily, was an account from the Berlin State Gazette, of a branch of a vine introduced into a hothouse, bearing flowers and fruit when the rest had none. Some, as M. Dutrochet, have imagined vegetables to have a nervous system, but never shown it. Dr. Brachet has lately contended for it, but the best botanists consider that this part of his book should not have been printed. The opinion has been thought proved by the action of certain poisons upon them. We know that they are poisoned like animals; arsenic, mercury, copper, lead, and tin, destroy them, and are found to be taken up by their vessels. Carbonic acid, azote, nitric oxide, hydrogen, when applied to the roots, are equally fatal. Opium, prussic acid, belladonna, nux vomica, menispermis coculus, hemlock, digitalis, alcohol, and oxalic acid, are no less so; and, because these destroy the life of animals without leaving chemical traces, and affect the nervous system, Dr. Marcet, jun., whose experiments will be found in the *Annales de Chimie*, June 1825, and are confirmed by many others, concludes that they must destroy vegetables by acting on a nervous system in them. But, although no trace be discoverable, this may be on account of their chemical peculiarities, (and, in fact, prussic acid and alcohol have been found absorbed, *Annales de Chimie*, Oct. 1814, and Dr. Cooke *on Apoplexy*,) and they, as well as other poisons, affect the nervous system of animals only as one part of the *living* body, — arsenic, besides its general deleterious agency, causing particularly gastritis, even if applied to a sore of the leg, digitalis exciting the kidneys (indeed their action on vegetables might, on the other hand, be urged as a proof of their *general* hostility to *life*); and the mineral ones, which often leave chemical traces, also produce peculiar effects on the nervous system, and often destroy life without being detected beyond the alimentary canal.

of the brain or spinal chord of course cannot be requisite, if there is no motion in the sympathy, nor any influence transmitted by nerves of voluntary movement. To the individual sympathy between the brain or chord these and their nerves must be indispensable, as in this respect they stand exactly in the condition of all other sympathising parts. When sympathetic pain is felt, brain and encephalo-spinal nerves must be required, the latter to communicate and the former to take cognizance of the sympathetic condition of the part in which the sympathetic pain is felt. But this is not an agency of the brain, chord, or encephalo-spinal nerves in sympathy: a sympathetic change first occurs in the part, and this is then felt by the encephalo-spinal system. If the ganglionic nerves have the office, assigned to them by so many writers, of giving vital properties to all parts, and not this, authors can hardly suppose that peculiar nerves for sympathy exist, seeing that all the other than the ganglionic are nerves for sense or motion or convey the influence of emotions from the brain: and, should distinct nerves for sympathy exist, I still cannot believe that the ganglionic system is for vitality on account of the reasons given above; and much less when I consider that its ganglia and nerves contain a large quantity of fibrils from the encephalo-spinal nerves of both sensation and motion; which very circumstance, I may remark, prevents me from believing that the anterior spinal nerves serve for motion only,—have no other function. I can conceive that the posterior are for transmission *to* the brain and chord only,—for sensation and for insensible influence, as when something unfelt in the stomach produces hiccup from the irritation being conveyed to the roots of the phrenic nerves: that the posterior are for transmission *from* the brain and chord; not however for the transmission of volition only, but of the influence of emotion and of excitement of their roots however induced. If we cannot always explain the occurrence or absence of sympathy by nervous distribution, we must remember that we are imperfectly acquainted with this. Fibrils often seem to unite which afterwards prove to run side by side only: and, the more knowledge we have, the more distinct do we find the office of individual fibrils. "Often," says Gall, "the different filaments of the same nerve are very visibly different: not only different nerves but also the threads of the same nerve proceed from different ganglia placed in different situations. All the peculiarities are the same in the same nerves; they must therefore

depend upon a primitive difference of inner structure, and be essentially necessary for difference of structure: whence Baron Cuvier naturally concluded that 'nerves are not all entirely alike, and do not all convey one fluid, like the arteries, for example; but that there are in the structure and mode of action of each, some peculiarity relative to the functions and nature of the organ which they animate.' I should say not animate, but influence." [r]

Sir C. Bell teaches that certain nerves are destined for Respiration and the Expression of the passions. These he terms respiratory nerves; and says they are the pathetic or internal motor of the eye, the portio dura of the seventh or facial, the glosso-pharyngeal, the eighth or pneumono-gastric, the accessory, the phrenic, and the long subclavicular or, as he terms it, external respiratory. These all arise, he says, in a tract, by him called respiratory, beginning at the mesocephalon, and descending on each side between the anterior or motor, and the posterior or sensitive, portion of the spinal chord, and terminating about the middle of the back. Chaussier [s] had previously pointed out the lateral tract, as suggested by Le Gallois [t], especially the portion contained in the skull, and suspected respiration to depend much upon it.

It is undoubted that several of these nerves are concerned in respiration and actions in which respiration is affected,—in sneezing, coughing, &c., as well as in the expression of the passions, in laughing, crying, and the expression of rage, terror, &c. But why the nerves of voluntary motion which are concerned in these actions should be regarded as different from other nerves of voluntary motion, I cannot imagine. Respiration is accomplished by muscles as voluntary as any voluntary muscles, and moved by nerves as voluntary as any other nerves of voluntary motion. We inspire because prompted to do so by uneasy sensation, just as we move from an uneasy posture. The pathetic, facial, accessory, phrenic, and long subclavicular, differ in no point from other nerves of motion; by their means we contract at pleasure the muscles to which they are distributed: in truth, the superior oblique muscle of the eye supplied by the pathetic, and some, as the orbicularis palpebrarum, supplied by the facial, have no con-

[r] Gall, l. c. 4to. vol. i. p. 128. sq., and 8vo. t. vi. p. 312. sq., where he quotes this part of the first 4to. volume under the name of *Mon Traité sur la Différence des Nerves.*

[s] *Exp. Sommaire, &c.* 1807.   [t] *Sur le Principe de la Vie.* 1812.

nection whatever with respiration. The motor nerves of respiration conspire in operation for a particular end. But so do the nerves of all other muscles: those of the lower extremity in walking, those of the upper and lower end of the trunk in rising from the recumbent posture. For any particular action whatever, instinctive or arbitrary, association of the action of the nerves of sets of muscles takes place. As to their action being instinctive and involuntary, the action of every voluntary muscle may be instinctive and involuntary; and is always involuntary if a motive of great strength exists. We breathe or wink unconsciously or involuntarily; so also may we run, withdraw an arm, leg, or whole body, unconsciously or involuntarily. It is true that respiration continues during sleep and a certain degree of coma; but other associated actions do the same which are voluntary. Patients will move any part unconsciously, if you make it uneasy during sleep: they will swallow in apoplexy till near death. Poor children, when fast asleep through fatigue, will continue to move their hands and fingers as if at work, even after the machines of their unprincipled employers have stopped.[u] Having begun any muscular actions, we continue them often unconsciously if our attention is directed to something else, and, on its ceasing to be so directed, we may be surprised to find what we are doing. Then as to the muscles supplied by these nerves being respiratory, there is hardly a muscle in the body which may not be respiratory. In dyspnœa, more and more muscles are employed in proportion to the difficulty, till at length almost every muscle of the four extremities may be called in to give assistance.— With respect to expression, every other voluntary muscle may give expression as well as those which are moved by the voluntary nerves above enumerated. In despair, we as instinctively wring our hands as we lengthen our features and bewail; in rage, we as instinctively clench our hands and toss our arms as we knit our brows and project our lips and vociferate; in joy, we as instinctively move briskly as we laugh; in surprise, we instinctively depress our lower jaw: — motions in none of which respiratory nerves have any share. I see no difference in the agency of these nerves and of all other nerves of voluntary motion. — Lastly, the glosso-pharyngeal appears now to be a pair not of motion, but of sense,

[u] *Report of the Factory Commissioners*, 1833. The inhuman facts detailed in this report cover our Christian country with shame, and may be retorted by Continental vivisectors with triumph against us.

and of a specific sense, — a deadly blow to the respiratory set of nerves; and the pneumono-gastric to be a pair both of sense and motion. The peculiarity of the improperly called respiratory nerves arising from a peculiar tract amounts to nothing, if these two nerves of sense also arise from it: and, if the other nerves do arise from a peculiar tract, still nothing can be inferred from the circumstance, since they are all voluntary nerves, and we have seen that their operations differ in nothing from those of all other voluntary nerves, when combinations of actions are required for particular voluntary or instinctive motions, or for the instinctive expression of the passions. The accessory, subclavicular, and phrenic, however, only are in general allowed to have the origin assigned to them by Sir C. Bell; and even the accessory is declared by Gall [x] to arise from the posterior (sensitive) roots of some spinal nerves. The respiratory tract, or column, is rather an anatomical fancy, for it is not always to be found, and the best anatomists deny its existence.[y] It thus appears to me that Sir Charles Bell's doctrine respecting the respiratory nerves is merely an untenable whim; and that his discoveries of the function of the ganglionic portion of the trigeminum pair, (its other portion having long before been assigned to motion by Paletta,) and of the facial, and of the excitement of motion on irritating the anterior roots only of the spinal nerves, — the whole amount, I believe, of his real contributions to the physiology of the nervous system, — are only sullied by his views of the functions of his respiratory set.[z] Even the two first of

[x] M. Manec says it often arises at a right angle from the posterior roots of some spinal nerves. *Anatomie Analytique.* Tableau.

[y] Dr. Spurzheim asked Sir C. Bell (*Appendix*, &c. p. 31.) whether it is true, i. e. whether it is not untrue, that "each lateral portion of the spinal marrow contains three tracts or columns, one for voluntary motion, one for sensation, and one for the act of respiration;" and "that a fasciculus may be traced down the spinal marrow between the sulci which give rise to the anterior and posterior roots of the spinal nerves." These are Sir C. Bell's words, in his *Exposit. &c.* p. 123. 129. — I said nothing of the origin of the anterior and posterior roots of the spinal nerves from an anterior and posterior lateral sulcus, when speaking of the anatomy of the chord, because Gall says he could find the posterior only and seldom lower than the first dorsal vertebra, and that the anterior roots do not proceed in a straight line and regularly, as M. Chaussier describes and represents in his plates, but confusedly, sometimes at one distance, sometimes at another, from the middle fissure; the very dots by which M. Chaussier represents the exits of the nerves, are farther from the middle line than the grooves. (Gall, 4to. vol. i. p. 61. sq.)

[z] Dr. Fletcher conceives that Sir Charles Bell is right, as far as he goes; yet

these three discoveries he has obscured by ascribing morbid phenomena dependent upon the motor branch of the trigeminus

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that the nerves arising from the respiratory tract serve not only for the sympathetic action, as he regards it, of respiration and the expression of the passions, but that they serve for the production of all sympathy and for the effects of instinct and the passions on the system; instinct being considered by him as a part of the passions, only attended by a desire and by actions adapted to a particular end, and the word passion being synonymous with emotion. The operation of passion or instinct and of sympathy may be regarded as the same: the various parts of the body sympathising only with the *brain* in the two first cases. Now instinctive actions may be actions of any voluntary muscles of the body, and their source must be certain parts in the brain, but the conveyance of the impression from these parts of the brain which are the seat of the mental operation must be to that other part of the brain or spinal chord whence the voluntary motor nerves which excite the respective muscles arise. No peculiar system of nerves is required farther for instinctive motion. Peculiar nerves or nervous fibres may exist in the brain and chord, or peculiar nerves may exist only between these and all parts of the body for the conveyance of the effects of the passions, and between the various parts of the body for their endless sympathies. Nervous communication there must be between all parts sympathising not through mere continuity, but the communications throughout the system by means of all the encephalo-spinal and ganglionic nerves are abundant enough for sympathy to occur between any two. Many of the very nerves which he regards as the specific agents of sympathy are voluntary nerves; the facial, pathetic, phrenic, are employed by our will; and I conceive that they no more excite muscles sympathetically than any other voluntary nerves, where the nerve is excited sympathetically through some other nerve communicating with their roots: the fact being that these nerves of motion may be stimulated at their source in the brain or spinal chord by the will, or by emotion or some other excitement operating sympathetically. Dr. Fletcher only makes it probable, in his own mind, that such general communications exist by these peculiar nerves. He argues, 1. That the respiratory system of nerves is likely to be distributed almost universally, because the ramifications of the pneumono-gastric are inextricably interwoven with the roots of the ganglionic nerves, which are presumed already by him to be universally dispersed by travelling with the blood-vessels, and which also reinforce every encephalo-spinal nerve, so that, wherever a ganglionic nerve goes, a so called respiratory twig may go likewise: this probable distribution of the pneumono-gastric nerve would be sufficient to establish the universal distribution of these nerves, though others of the set are probably very widely disseminated. In fish, the pneumono-gastric is universally distributed. This set of nerves have almost a common origin, so that by means of one's diffusion, the whole may be regarded as diffused. Thus the sympathy between the lungs and the respiratory muscles is maintained by the pneumono-gastric nerve distributed to the lungs and conveying the sensation of want of breath; by the phrenic and intercostals and accessory and external respiratory nerves, which are associated at their roots with it, and excite the muscles as well as by other muscular nerves, the pathetic, facial, and even

nerve to affection of the ganglionic portion and of the facial, and by considering the facial as exclusively controlling all motions

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those distributed to numerous muscles of the body when the irritation from dyspnœa is extreme. The pneumono-gastric and the rest of the set associated with it at their roots appear to maintain the sympathy between the heart and the rest of the system. — I reply that he allows the ganglionic nerves to be as widely distributed; and so indeed must be the nerves of sensation, for any vascular part of the body may show sensibility when inflamed.

2. He argues that the nerves of sensation cannot convey sympathy, because this may occur independently of sensation and some sympathising parts have no sensibility.—But all vascular parts may acquire sensibility under inflammation, and therefore all vascular parts must have nerves of sensation. Yet sympathy may doubtless occur without sensation, just as the various nutritive functions occur without it. Still, if the ganglionic nerves are allowed by him to administer to these, *they* may administer to sympathy. Indeed, sympathy is often the result of sensation only. We do not sneeze unless the sensation in the nose arises to a certain height, — not the sensation of smell, but of touch; and I may remark that Dr. Fletcher appears wrong in arguing that sensation in the nose does not occur before sneezing, because it is not the sensation of smell. Some sympathies are sensations and therefore carried on in some measure at least by nerves of sensation; other sympathies certainly can have nothing to do with nerves of sensation, but it does not follow that they must be carried on by the so called respiratory nerves.

3. The occurrence of sympathy during sleep he considers an argument that sympathy is independent of the brain.—No one can doubt that many sympathies are independent of it. Communications of nerves exist independently of the brain: and Dr. Fletcher is correct in condemning the old hypothesis that the brain is necessary to sympathy. Still this does not show that the so called respiratory nerves must be the sole organs of sympathy.

4. He maintains that the manifestation of the effects of sympathy, passion, and instinct, are in proportion to the development of this system.—Certainly, in proportion to the *voluntary* muscles, which act under instinct and passion, are the nerves which serve these *voluntary* muscles. Fish, he urges, have, of the respiratory nerves, only the pathetic and the pneumono-gastric, which latter is in part a nerve of motion like the pathetic, and they have it of great size. Fish display the effects of many instincts and passions. Reptiles have, in addition, the glosso-pharyngeal and facial. Similar additions of other nerves are found in other classes. The glosso-pharyngeal, however, is now proved to be a nerve of special sense, and the facial supplies the voluntary muscles of the jaws and fauces, which in fish were supplied by the pneumono-gastric. But I can see here no argument for these voluntary nerves being exclusive agents of sympathy, although they are used as excitants of voluntary muscles under instinct and passion, and in morbid involuntary excitement of these muscles as well as in volition.

5. The structure of the sensiferous and ganglionic nerves is similar; and of

of the face concerned with respiration and expression, when the mere descent of the lower jaw which accompanies surprise proves the aganglionic portion of the trigeminus nerve to be, as almost any nerve of voluntary motion may be, a nerve of expression.[u]

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the motiferous and respiratory. As the motiferous convey a stimulus, so therefore probably do the respiratory.—Unquestionably those which are voluntary nerves are like all other voluntary nerves. Such are the facial, phrenic, and partly the pneumono-gastric, which are similar to the common motor of the eye, the abductor, and the hypo-glossal. This really tends nothing to the argument. Indeed the analogy does not hold with respect to all, for the glosso-pharyngeal, however similar in structure to nerves of motion, is a nerve of sense.

6. The sensiferous and ganglionic nerves do not transmit the galvanic influence; while the motiferous and respiratory transmit it with facility.—But this proves no more than the fifth argument; and I know not that all the latter do.

7. A stimulus applied to the trunks of these nerves occasions in general a display of irritation in parts sympathetically connected with them.—I believe this is the case with all nerves of motion, as well as those concerned in the motions of respiration. Stimulation of even nerves of sense will often excite those of motion which are sympathetically connected with them. Indeed, the acceleration of respiration after a time is said to follow the irritation of the glosso-pharyngeal — a nerve of only specific sense, as much as of the accessory and pneumono-gastric.

8. When the respiratory nerves are divided, the effects of passion and sympathy upon the parts which they supply are lost.—This is true of those which convey the effects of volition,—for this they can do no longer, nor, of course, can they convey involuntary any more than voluntary excitement to the muscles to which they run. But the fact amounts to no more than would be true of the division of any nerve of voluntary motion. The division of the glosso-pharyngeal can have no such effect, — for, being a nerve of sense, its sense (taste) only is lost in the part which it supplies. Various disturbances follow the division of the pneumono-gastric, but various ill effects also ensue upon the divisions of the sensiferous fifth.

Although I consider Dr. Fletcher's views equally unfounded with those of Sir C. Bell, I must not omit to mention that he puts them forth most candidly and rationally as purely hypothetical, and intended to give way to whatever shall be proposed of a more satisfactory nature.

It may be well to mention here that Sir Astley Cooper has lately published an account of the ligature of the two great sympathetic nerves in rabbits, and found no evident effect. One rabbit was killed at the end of seven days, when one nerve was found ulcerated through and the other nearly so; another rabbit was alive, at the end of a month, when the account went to press. (*Guy's Hospital Reports*, No. iii.)

[u] For his three discoveries Sir C. Bell deserves great praise, and his name will endure as long as the physiology of *these respective nerves*. But, when

credit is given him for having made discoveries, some of which belong to others, and some of which are no discoveries at all, but fancies; and when so much that to me is unintelligible, so much error, so much want of extensive knowledge, pervade his writings, I cannot refrain from smiling at the expressions splendid, brilliant, profound, luminous, and I know not what others, applied to his opinions by persons who cannot have considered the subjects laboriously, and only imitate one another in their belief and their language. The most ludicrous eulogy is in the *Report of the Third Meeting of the British Association.* Dr. W. C. Henry says, "The honour of this discovery (that there are distinct nerves of sensation and motion), doubtless, the most important since the time of Harvey, belongs exclusively to Sir C. Bell." (p. 62.) Now no new principle was discovered. We knew before that some nerves, as the optic and olfactory, were for sensation only, and some, as the common motor, the external motor, and the internal motor of the eye, and the lingual, for motion only. The only discovery was that two individual nerves were, one for the first function and the other for the second. That no one nerve could be for both sensation and motion had always been evident to reflecting minds. Galen taught his cotemporaries that one set of nerves went to the skin for sensation, and another to the muscles for motion. That Sir C. Bell had no idea that the anterior spinal roots were for motion only and the posterior for sensation only, is evident from the fact that above ten years after he had found motion to depend upon the anterior roots only, his able nephew, the late Mr. John Shaw, who lived with him and acted under him, published a paper * in which he says that his uncle is of the same opinion as Galen, and mentions the experiments of his uncle showing the connection of the anterior roots with motion, but has no idea that they are for motion only and not for sensation also, nor that the posterior are for sensation. His words are, —"These experiments we have often repeated, and always with the same results; but from the violence necessarily used in making them, it has been difficult to ascertain which of the filaments bestows sensibility on the part. It was easily shown that if only the posterior set was destroyed, the voluntary power over the muscles continued unimpaired, but the pain necessarily attendant upon the performance of the experiment prevented us from judging of the degree of sensibility remaining in the part." (p. 148. sq.) Now this paper was read on the last day of April, and printed in July, 1822, and Dr. Magendie's discoveries of the distinct functions of the two roots appeared in August (*Journ. de Physiol.*); so that, though Sir C. Bell refers to it in triumph (*Nervous System,* Preface, xxii.) as a proof that he had made the discoveries before Dr. Magendie, it proves precisely the reverse, and exhibits the imperfect state of his views up to the very time of Dr. Magendie's discoveries. Numerous as have been Dr. Magendie's physiological errors, humbly as I estimate his knowledge and reasoning powers, and much as I abhor his cruelty to brutes, I have never known him dishonourable; and I am satisfied that he knew nothing of Sir C. Bell's original discovery respecting the anterior nerves, for it was communicated in a pamphlet privately distributed: and as to the discovery of the office of the posterior roots, it, and thus the exact division of office between the two, is certainly Dr. Magendie's.

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* *Med. Chir. Trans.* vol. xii. 1822.

After all, I do not believe the whole discovered; because filaments from the anterior, as well as from the posterior roots, go to the sympathetic ganglia, and certainly not for motion. Gall had proved, in the last century, that distinct parts of the nervous system had distinct offices. This he taught in opposition to many of the most noted of his cotemporaries: he taught it with respect to the grand nervous organ — the brain, and with respect to the universal divisions of the nerves. (l. c. 4to. vol. i. p. 131. sq.) Sir C. Bell's discoveries are simply individual examples of Gall's great general principle in merely nerves. So little, however, does the gentleman entrusted to report for the Association know of Gall's discoveries, that he not only thus ventured to address it, but, after detailing the unsatisfactory vivisections of Messrs. Fleurens and Magendie, he passes Gall's labours over in silence, and gravely informs the assembled *savants* that there does not exist any conclusive evidence for referring separate faculties, or moral affections, to distinct portions of the brain." (p. 90.)! Phrenologists should really not allow the Association thus to expose itself.

Since the preceding sheets were printed, I have seen the paper by Professor Ehrenberg, alluded to *suprà*, p. 324. 325., in which he asserts, in opposition to M. Raspail, that, by means of the microscope, he has found the fibres of the encephalon, spinal chord, and nerves to be tubular. The following is pretty nearly his own summary of his observations: —

1. The fibrous substance of the brain consists not of solid fibres, but of parallel or fasciculated tubes, dilated at intervals, or jointed, and from $\frac{1}{96}$ to $\frac{1}{3000}$ of a line in diameter. Conveyed from the surface towards the ventricles and basis, increasing in size, and not united by any visible medium, they pass into the spinal chord, which they in a great measure constitute.

2. The brain, a central organ in function, is a peripheral in structure, as Gall had already remarked, and not to be compared with the heart or stomach as central organs.

3. The spinal chord of man, and of all great divisions of vertebrated animals, consists of tubes similar to those of the brain; but the finer tubes are placed more inwardly, the thicker outwardly. The thicker are continued into the cylindrical tubes of the spinal nerves.

4. The three soft (higher) special nerves of sense, — the olfactory, optic, and acoustic, and the sympathetic, consist of tubes which are collected into fasciculi and surrounded by neurilema. The three are immediate prolongations of the white matter of the brain: the sympathetic has a mixed structure of jointed and cylindrical tubes.

5. The jointed tubes of the brain, spinal chord, and articulated nerves, contain a perfectly transparent tenacious fluid, never visibly globular, the *liquor nerveus*, which differs from the *nervous medulla* as the chyle does from blood. Visible motion of this fluid has not been satisfactorily observed: a slow progression, however, is probable

6. All other nervous chords consist, not of jointed tubes, but of cylindrical

larger tubes, collected into bundles. These tubes are the immediate prolongations of the jointed tubes of the brain and spinal chord, for the most part suddenly changed and deprived of their dilatations, and are surrounded by neurilema. In the invertebrata they are from $\frac{1}{48}$ to $\frac{1}{1000}$ of a line in diameter: in the vertebrata from $\frac{1}{120}$ to $\frac{1}{240}$. They contain a granular, and, as it were, congealed, medullary matter, that by gentle pressure can visibly be forced out from them, after which they appear as empty sheaths, &c.

7. Hence the nervous substance consists of jointed tubes carrying the *liquor nerveus*, and cylindrical tubes with true *nervous pith.*

8. The brain does not consist of *nervous pith.*

9. The invertebrata do not possess a spinal chord consisting of jointed tubes without *pith;* or, in other words, the invertebrata *have no spinal chord,* although their abdominal ganglionic chord, which consists chiefly of cylindrical tubes containing *pith,* may perform the function of a spinal chord.

10. In the invertebrata the jointed cerebral substance and blood globules appear in much less proportion.

11. The jointed nervous tubes are, in relation to the human organisation and their distribution in the animal kingdom, the more important and *noble* part of the nervous system, and more immediately subservient to sensation.

12. Almost all cerebral terminations (only less obviously in the ear) are pervaded by a network of vessels, and contain large scattered globules, the size of which has a constant ratio to that of the blood globules in the same animal.

13. The structure of the retina, even in man, has been hitherto very erroneously described. The granular layer of the anterior surface of the retina is pervaded by a network derived from the central vessels. Behind this is placed the expansion of the optic nerve, which consists of jointed tubes, and separates into a peripheral cortical, and a central medullary matter. Many single, scattered, club-shaped bodies appear to moderate the luminous impression. Their connection with the jointed tubes of the nerve, Professor Ehrenberg could not clearly make out.

He confirms the discoveries of old anatomists mentioned above at page 341, respecting the pulpy (cortical) substance,—that it consists of a thick but delicate vascular network, and a soft substance; and the latter he pronounces to be finely granular, and to contain numerous insulated larger granules, which are composed of smaller ones, strung on filaments, as far as it was possible to observe them. Near the fibrous (medullary) portion of the brain, the filaments of the pulpy (cortical) substance become more and more evident, and the blood vessels somewhat larger and much less numerous. These observations greatly strengthen Gall's opinion of the pulpy (cortical) substance being the source of the fibrous (medullary): and Ehrenberg farther states, we see (12), that almost all the terminations of the cerebral nerves are again contained in a dense vascular network, with scattered globules, which he conjectures to be the *nuclei of blood globules,* especially as these in the pulpy substance of the brain are *proportionate to the size of the blood globules of the animal.*

Gall, it must be remembered, conceives that the nervous fibres originate, not only in the pulpy portion of the encephalon and chord, but in the peripheral extremities, where also pulpy substance, he urges, is found. In the pulpy portion of the ganglia, similar granules have been discovered by Ehrenberg, so

that at least one great use of the ganglia of the sympathetic, as of the encephalo-spinal system, may, with still further probability than I urged at page 451. *sq.* be to reinforce the substance of the nerves; and the opinion of Gall respecting the use of the pulpy substance of the nervous system, supported by his most powerful arguments, though rejected on the most silly grounds by Dr. Tiedemann, has acquired more probability than ever. The series appear to be externally abundant blood vessels, though fewer and fewer inwards; next granules, probably the nuclei of blood globules; and, lastly, the fibrous structure, now pronounced to be tubular.

Beobachtung einer auffallender bisher unerkannten Structur des seelenorgans bei Menschen und Thieren. Von C. G. Ehrenberg. Read Oct. 24. 1833. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin,* 1834.

CHAP. XX.

VOLUNTARY MOTION.

The processes of every living system, like those of inanimate nature, are carried on with *motion*.

"By ceaseless action all that is subsists."[a]

It is implied in the circulation, secretion, nutrition, and absorption of the minutest vegetable and animal; and, generally, when observation is possible, the solids, no less than the fluids within them, are seen in these functions to move.[b] Some contend, though without proof, that the nervous functions are performed with motion of a vibratary kind. The evident motion of the brain from circulation and respiration, and the very much larger quantity of blood constantly passing through the brain and other nervous parts than mere nutrition (unless each functional act causes waste of solids) can require, and this in proportion to activity of function, show that in one sense motion is indispensable even to nervous function. The other functions by which fresh substance from without is obtained, the blood purified, the new animal originated, and indeed all those other functions and modes of function which distinguish animals from vegetables, take place with manifest and considerable motion, and, though vegetables have not the power of locomotion, the leaves and flowers of many of them move rapidly and considerably. Now motions of the leaves, flowers, and vessels of plants are evidently the result of life, and are inexplicable by mere gravity, electricity, &c. No peculiar known structure is united with their movements. Some

[a] Cowper. *Task.*

[b] We witness vegetable fluids passing along surfaces and through cellular structure; and fluids in some adult animals through such a structure; and in all before a heart exists, or even vessels at the spot. Many declare that particles move spontaneously not only in blood (Dr. Tiedemann, l. c. cclxv.), but in the juices of plants (cclxxxvii.), (ccccIxxxiii. sqq.) (also dlxx.). Perhaps some of these motions are to be explained by the absorption and emission of fluid, some by evaporation, some by chemical processes altering the position of particles, and some by extraneous impulse. In many animals we shall see that the movements of fluids upon surfaces arise from the vibration of hair-like projecting bodies, termed cilia.

animals consist of substance as soft as mucous or gelatinous tissue; for instance, the polypi, most radiaria, some entozoa and the infusoria: yet the former will swim or crawl, attach or detach themselves, and seize prey; the infusoria swim rapidly, turn, and avoid each other, and possess distinct muscles. Sedatives and stimulants affect these movements of vegetables and of such animals like those of large animals. Such vegetables and animals, as well as minute insects and infusoria, which evidently perform what in large animals we should term muscular movements, show that living structure, though so soft that it cannot be regarded as precisely similar to the flesh of large animals, — to muscular fibre,—to what is termed muscle, is capable of living contraction. Such minute voluntary actions are attended, Raspail declares, in one infusory animalcule—the rotifer, by thickening during contraction of the muscular cylinders running from its head to its tail, and by tenuity of them when they lengthen.[c] In animals possessing muscles, many parts, not apparently muscular, contract, and instantaneously and forcibly, by a living force. Such are minute vessels and canals of all kinds. These lose their contractile power, like muscles, immediately or soon after death. Some structures are most adapted for contraction, as muscles; others not at all, as tendons and bones: but others, though not evidently muscular, possess the faculty in various degrees; and to expect distinct muscular fibre in every excitable part would be erroneous.

The vital power of motion, whether sensible, as in the heart and voluntary muscles and the leaves and flowers of many vegetables; or insensible, (except by its effect on contained fluids) as in the minute vessels of vegetables and animals, may have the term *excitability* restricted to it (see *suprà*, p. 25.), and thus will be distinguished from *sensibility*, to which the idea of motion is not necessary, as seen in the terminations of the optic and olfactory nerves, though motion may follow sensation; and sensation again is not necessary to motion, for not only do many animal motions occur without sensation, but vegetables are utterly destitute of sensation. The term *irritability* was peculiarly given by Haller[d] to the

[c] l. c. § 497. Dr. Tiedemann says that, with a microscope and strong lens, he observed contractions and expansions in the simplest infusoria, l. c. dlxxv. though previously he had asserted that neither could be detected in them, cccclxiii.

[d] " See Haller on the irritable parts of the human body, *Commentar. Soc. Sc. Gotting.* t. ii.

excitability of parts which both move evidently from the application of stimuli, and possess distinct fibres; and he therefore said that muscles only are irritable[e], though other animal parts, as well as vegetables, possess excitability, — move independently of gravitation, or chemical or electric circumstances, or mechanical impulse. To deny this power, styled also by Haller *vis insita* or *propria*, to parts which may not show muscular fibres, or which may not move evidently on the application of a stimulus, would be absurd; yet Haller did this. To avoid confusion, the term myotility is given to the power of instant and evident contraction of fibrous parts on the application of a stimulus: it is

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And *Nov. Commentar. Gotting.* t. iv.

Among innumerable other writers on the same subject, suffice it to quote the following: —

Zimmerman, *De irritabilitate.* Gott. 1751. 4to.

Oeder, on the same. Copenhagen, 1752. 4to.

J. Eberh. Andreæ, on the same. (Præs. Ph. Fr. Gmelin.) Tubing. 1758. 4to.

As well as three entire Collections of writings which related to the great controversy excited throughout Europe in consequence of the Gottingen publications.

Sull' Insensibilita e Irritabilita, Dissertazioni transportate da J. G. V. Petrini. Roma, 1755. 4to.

Sulla Insensitivita ed Irritabilita Halleriana opuscoli raccolti da G. B. Fabri. Bologna. 1757—59. iv. vol. 4to.

And what were published under Haller's inspection, *Mémoires sur la Nature sensible et irritable des Parties du Corps Humain.* Lausanne, 1756—59. iv. vol. 12."

[e] Our countryman, Dr. Glisson, whose portrait we possess in the College of Physicians, was the first who absolutely ascribed animal movement to a specific power, which he termed irritability, (*De Natura Substantiæ energetica, seu de Vitæ Natura.* London, 1672. 4to.), — to a property of being influenced by excitants; and he distinguished it from sensibility. He pointed out that it might occur without sensation, with sensation, or through the will, — "Irritatio est perceptio, sed sensatio est perceptio perceptionis." Yet his facts, for his statements of the existence of such a *living* power were no theory but facts, found no supporters, Dr. Tiedemann remarks, (l. c. dxxvi.) "among his contemporaries, blinded as they were by the system of chemistry and iatro-mechanics, and were only justly appreciated in the following century."

Dr. De Gorter pointed out that the former is possessed by all parts of living bodies and by vegetables also. (*Exercitationes Medicæ quatuor.* Amstel. 1734. 4to. *Ex. Med. quinta.* Amst. 1748. 4to.) Dr. Glisson had allowed excitability even to the blood and humours, and Dr. Gaubius of Leyden afterwards did the same. (*Institutiones Pathologiæ.* Leyden, 1758. 4to. p. 169.)

synonymous with the two words — muscular contractility; but we must regard the power as the same with that which produces the motions of the minute vessels of all kinds of minute or gelatinous animals, and those rapid motions of some animal and vegetable parts which show no fibres, — we must regard it as a form of excitability. The term irritability should have a more extensive meaning than excitability: for, while this implies motion, irritability implies the general power of being affected by irritating causes, whether manifested by direct motion or by other changes which show either sensation or an operation distinct from what is seen in inanimate bodies: it is in truth vital affectibility in the largest sense.[f]

" The muscles, which are the immediate organs of by far the greater number of our motions, form the greatest bulk among all the similar parts."

" They are distinguished from other similar parts chiefly by two characteristic features, the one derived from their structure, the other from their remarkable powers.

" Their fleshy structure is formed of moving fibres, *sui generis*, and of a very faint red colour, and every muscle may be resolved into fibrous bands, these into bundles of fibres, and these again into very fine fleshy fibres and fibrils.

" Every muscle possesses a covering of cellular membrane[g], which is so interwoven witn its substance as to surround the bands, the bundles, and even each particular fibre and fibril.

" Every part of the muscles is amply supplied with blood-vessels and nervous threads. The latter appear to deliquesce into an invisible pulp, and unite intimately with the muscular fibres: the former are so interwoven with the fibres that the whole muscle is red and acquires its own paleness only by being washed.

" Most muscles terminate in tendons[h], which are fibrous[i] parts, but so different in colour, texture, elasticity, &c., as to be readily distinguished from muscles: thus disproving the opinion of some, — that the tendinous fibres originate from the muscular. This error arose chiefly from the circumstance of the muscles of infants

[f] In my own use of terms, at note ([e]) p. 24, 25. *suprà*, irritability and irritation, should be substituted for excitability and excitement.

[g] " See Ad. Murray, *De Fascia Lata*. Upsal. 1777. 4to."

[h] " See Fourcroy, *Mémoires de l'Académie des Sciences de Paris*, 1785, p. 392.; and 1786. p. 38."

[i] " Albinus, *Annotat. Academ.* l. iv. tab. v. fig. 2."

containing a greater number of fleshy fibres, in proportion to the tendinous, than those of the adult."

"They are in general divided into hollow and solid. The first, not directly subject to the will, belong more to the vital and natural functions." They are the heart, one of the coats of the alimentary and respiratory canals, of the urinary bladder, and of some blood-vessels; and are seen in a few other parts. They shorten and narrow the cavity or canal which they surround.

"Among the second," which are subject to the will, "there is much variety. For, not to allude to difference of size, there is great diversity in the disposition of their bands and fasciculi, the direction of their fibres, the proportion of the fleshy to the tendinous part, their course, mode of insertion, &c.

"The greatest number are long, and their fleshy bellies," lying outside solid parts, and passing over one or more joints, "terminate at each extremity in tendinous chords, inert, and destitute o contractility, and fixed to different bones, which, while contracting, they move in the manner of levers." The movable solids are drawn towards each other, if of equal mobility and size; if not, that which is movable or more movable and small is drawn towards the other.

"The commonly received law—that a muscle during its contraction draws the more movable point of insertion to the more fixed, must be considered, as Winslow justly remarks[k], perfectly relative and subject to various limitations. Thus, for example, sometimes the one point, and sometimes the other, may be the more movable, accordingly as the *united* action of many different muscles may render the opposite more fixed."

"While a very few muscles are destitute of tendons, such as the latissimus colli, an equally small number are not inserted into bones," but into soft solids, as into the lips, palate, tongue, pharynx, nose, eye, ears, genitals. These approach the hard part during contraction.

"A property common to all muscles is to become shorter, more rigid, and generally unequal, and, as it were, angular, during contraction," gaining in thickness what they lose in length. Dr. Tiedemann argues that, in contracting, a muscle acquires greater density, because it will support or raise a weight which would tear it after death. This, however, shows only the more

[k] "*Mém. de l'Acad. des Sc. de Paris.* 1720."

perfect composition of the part during life than after death. A muscle, however, may act, without shortening or growing thicker. If we hold, or act upon, a resisting body without moving it, the muscle, though in action, does not shorten. Again, a muscle may be made to shorten without contraction. We can bend the extremities of a person asleep, and thus his flexors be passively shortened.

"To attempt, with J. and D. Bernouilli and other mathematical physicians, to reduce the shortening of muscles to a general admeasurement, is rendered impossible, by the great difference, among other causes, between the hollow and solid muscles in this respect, and between the solid muscles themselves, *v. c.* between straight muscles (such as the intercostals) and sphincters."

Some have peculiar actions, dependent upon figure, situation, &c., "and, consequently, varying so much as to be referable to no general laws.

"To cite one instance out of many, that action of certain muscles is peculiar and anomalous which seldom occurs alone, but nearly always *subsequently* to, or *simultaneously* with, the action of some of a different order. Such is that of the lumbricales, when, during rapid motions of the fingers, they follow the action of other muscles of the metacarpus and fore-arm; and of the lateral recti muscles of the eyes, the adducens of either of which seldom acts unless simultaneously with the abducens of the other eye.

"And, on the other hand, although the action of the flexors is generally so much stronger than that of their antagonists — the extensors, that, when the body is at rest, the arms, fingers, &c. are a little bent, this does not so much depend upon the strength of the contraction of the flexors, as upon the voluntary relaxation of the extensors for our own relief.

"Every muscle has, moreover, a peculiar *mechanism*[1], adapted to the individual motions for which it is intended.

"Besides the determinate figure of each, many other kinds of assistance are afforded to their peculiar motions, *v. c.* by the *bursæ mucosæ*, chiefly found among the muscles of the extremities; the annular ligaments by which some are surrounded; the fat in

[1] "P. J. Barthez, *Nouvelle Méchanique des Mouvemens de l'Homme et des Animaux.* Carcass. 1798. 4to."

which most are imbedded; the lymphatic vapour around each; and, above all, by the conformation of the skeleton, chiefly in regard to apophyses, condyles, and articulations; nay, even whole bones, *v. c.* the patella, the pisiform of the carpus, and the sesamoid bones[m], are destined solely to facilitate the actions of certain muscles.

"In this mode is compensated, or, at least, diminished, that inevitable loss of power which necessarily takes place from the conformation and stature of the whole system, as, from the acute angle at which some muscles are inserted, or the proximity of their insertion to the centre of motion, much of that power is lost which would have existed, if their insertion had been more remote or at a more obtuse angle.[n]

"The human body, possessing about 450 voluntary muscles, or upwards, according to sexual or individual variety, is thus furnished with a double advantage, — with an extreme agility of motion in particular parts and throughout the whole, and with a surprising degree of strength and endurance of labour. Both these are accomplished partly by the perfection of the muscles that, like the perfection of the bones, takes place at manhood; and partly by habit and practice, the power of the former of which in affording strength and agility to the muscles is demonstrated in rope-dancers, leapers, runners, wrestlers, porters, savages, and the examples of ancient nations."[o]

When a muscle has ended its contraction, antagonising muscles, the elasticity or gravity of parts, solid, fluid, or gaseous contents pushed forwards from the higher portions of the canal, &c. &c., are enabled, through its diminished resistance, to elongate it. The mere cessation, however, of its contraction must be supposed to lengthen a muscle. For if, while under the exertion of a force drawing it together it is of a given length, this cannot remain the same when this force is no longer exerted. But any great elongation of it is accomplished by antagonising powers. When the heart has contracted, its relaxation is said, as we have seen, to be

[m] "Hence, of all animals which I have dissected, the mole is supplied with the most remarkable apparatus of sesamoid bones; its anterior palmated feet, with which it digs, have many of these bones, which greatly facilitate the action of the brachial muscles."

[n] "Gilb. Blane, *On Muscular Motion*, p. 51."

[o] "I have treated on this point at large, in the *Medic. Biblioth.* vol. ii. p. 407."

attended with an active enlargement of the organ forcing it energetically against the hand if placed upon it.

We will now consider the anatomy and physiology of the ultimate muscular fibre. Mr. Hare affirms that, in the field of a moderately powerful microscope, a muscular fibre evidently appears made up of numerous minute tubes, each exhibiting longitudinal striæ with transverse bands; the average diameter of each of these ultimate fibres or tubes being $\frac{1}{400}$ of an inch.[p] Under contraction, the portions between the transverse bands draw the latter nearer together, and, swelling out, seem girted by them, so that the whole fibre somewhat resembles a string of eggs. This appearance, Mr. Hare supposes, led Dr. Croon to adopt the idea that the ultimate fibre of muscle was constituted by a chain of bladders filled with fluid. In fact, Mr. Bauer thinks he discovers muscular fibres to be chains of globules[q], and Prevost and Dumas declare the same from their microscopic observations.[r] The muscular tubes are represented by Mr. Hare as filled with a matter which causes them to appear solid till it is liquefied by heat: Mascagni describes the muscular fibre as a small cylinder, filled with glutinous matter.[s] Fontana asserts that the primitive muscular fibre is marked by continual minute crispations and nodosities, and that it pursues a straight course, but is solid like the tendinous. Meckel, Rudolphi, and Tiedemann believe the primitive muscular fibre solid. Dr. Hodgkin found it not to consist of globules, and to be marked by transverse lines, which he thinks distinguish muscular from all other fibres. Raspail, like Mr. Hare, corroborates the assertion of Mascagni. He declares that every muscle, like the adipose texture and vegetable organs in general, consists of cells inclosed within each other in an indefinite series; but that, whereas their cells approach to a spherical form, those of muscle are cylindrical. The ultimate cylinders are closely applied to each other in very loose spirals round an imaginary axis; and each is full of a substance not completely miscible with water; and here and there globules appear irregularly, in contact with the inner surface. In the bullock,

[p] Thomas Hare, *A View of the Structure, Functions, and Disorders of the Stomach, &c.* p. 28. sq. 1821.

[q] *Phil. Trans.* 1818. J. F. Meckel, by microscopical observations, fancies the muscular no less than the nervous fibre, and the substance of the liver, kidney, spleen, &c., to be globular.

[r] *Annales de Chimie*, t. xviii.

[s] *Prodromo.* p. 97.

each cylinder is ·002 of an inch in diameter, and slightly crimson.[t] A bundle of cylinders is enveloped in a membrane; and such masses are enveloped in another membrane; these larger masses in others; till all have one general outer covering, which is usually white and hard towards its extremities, and terminates in a white shining chord called tendon and inserted into periosteum.[u] The fibres of tendon are said to be really solid, of infinitely smaller diameter, and disposed in a reticulated manner. Even cellular membrane is said to consist of reticulated tubular fibres, $\frac{1}{1000}$ of an inch in diameter on the average, and exhibiting transverse contractions.[x] Fontana, by means of glasses of moderate powers, found tendon to be composed of bands, which again are composed of solid spiral cylinders, of uniform size, and pursuing a tortuous course.[y]

M. M. Prevost and Dumas assert that the muscular fibres, straight while at rest, approximate each other at intervals, under contraction, so as to acquire a zigzag course (\/\/\/\/) and shorten the distance of their two extreme points[z]; and thus Dr. Hales remarked that, when the abdominal muscles of a frog contracted, "the scene instantly changed from parallel fibres to series of rhomboidal pinnulæ, which immediately disappear as soon as the muscle ceases to act."[a] They ascertained satisfactorily that during contraction no increase of volume is acquired If muscles, while the fibres are straight, are stretched still more, as continually happens in the muscular coats of cavities, the subsequent shrinking to the original dimensions is unattended by the zigzag appearance. Nervous filaments, they also assert, go perpendicularly to the muscular fibre at the very points where the angles are formed under the zigzag contraction, and yet not to terminate there or unite with the muscular fibres, but to return to the same nerve or anastomose with other nerves. The approximation of the nervous filaments to each other is thought to draw the muscular fibres into angles, and thus be the cause of muscular contraction. But Raspail objects that it is hard to conceive how

[t] "The ultimate muscular filament has been estimated at $\frac{1}{4000}$ of an inch in diameter: their union forms fasciculi. Prochaska says that 200 fasciculi form a bundle; these are from $\frac{1}{8}$ to $\frac{1}{10}$ of an inch in diameter." Dr. Tiedemann, l. c. p. 418. additional notes by Drs. Gully and Hunter Lane.

[u] *Nouveau Système,* § 490. sqq.

[x] Mr. Hare, l. c. p. 36.

[y] *Sur les Poisons,* t. ii. p. 230. sq.

[z] Dr. Magendie's *Journal de Physiologie,* t. iii.

[a] *Hæmastatics,* p. 59.

elastic filaments could form lines so sharply angled; that he himself could not distinguish by the microscope which filament belonged to nerve and which to muscle; and that, if MM. Prevost and Dumas did see something like what they represent, their experiment was worth nothing, because, the muscular lamina being in contact with the object-holder in many points, any tremor caused mechanically or by galvanism applied to the nervous fibre would produce sinuous movements which afterwards were supposed more or less regular and angular. In short, he truly says that the only rational mode of observation is with a living muscle in action; that he has carefully watched the contraction of the muscles of the feet of gasteropoda, &c. and always found the fibre simply shorten, its diameter increasing at the time and small swellings appearing throughout its length.[b]

Dr. Wollaston[c] states that muscular contraction is accompanied by a *vibratory* sound like that of carriages passing rapidly over a pavement at a distance; and infers that it is not continuous but intermitting, consisting of a number of contractions repeated at extremely short intervals: and he fancied that such vibratory alternations might be about twenty or thirty in a second. He applied the ball of the thumb to the ear, pressing the end of the thumb at the same time against the head. As soon as the thumb is bent so as to press against the head, the noise is heard; and I find it far louder if both thumbs are used at once, and still louder if the jaws are at the same time tightly closed. In regard, however, to the intermittence of muscular action, a friend informs me that the action of the muscles of the eye cannot intermit even the 2000th part of a second, because, if a luminous point is moved with rapidity perpendicularly, and the eye horizontally, the luminous line is not a zigzag, as it would be were there intermissions, but perfectly continuous.[d]

The muscles, voluntary and involuntary, of all animals in which a nervous system has been discovered, contain nerves; for the will operates by encephalo-spinal nerves on the voluntary muscles, and the stimulating contents of involuntary muscles do not act, except by distension, directly upon them, but upon a membrane

[b] l. c. § 494. sqq. [c] *Phil. Trans.* 1810, p. 2. sqq.

[d] Two curious cases are related in Dr. James Johnson's *Med.-Chir. Review*, Oct. 1834, of the action of muscles occurring with a cracking noise like that of snapping joints, and with pain.

which lines them, as in the case of the heart and blood-vessels, the alimentary canal, and other hollow muscles, nor does light act upon the iris but upon the retina, and the influence of emotions, sudden or continued, on the action of all involuntary muscular parts, whether large, like the heart and as in the alimentary canal, or minute, as in the capillary vessels, must be communicated by nerves. Some vivisectors say that a stimulus applied to the nerves of an involuntary part do not excite it; others assert the reverse. But any stimulus applied to a nerve belonging to a voluntary muscle, mechanical or pungent, heat or electricity, excites it instantly to action, and will excite it after pricking or cutting the fibres themselves has ceased to produce contraction.[e] Stimulation still further back, of certain parts of the chorda spinalis or oblongata, or of the brain, has the same effect. Division of the nerves or spinal chord, great compression, disintegration, any thing which prevents continuity of influence from the brain to the termination of the nerve in the muscle, destroy the power of the will. The contractility of the muscle is of course unimpaired; it contracts equally as before, if a stimulus is applied to it or to the portion of the nerve connected with it. Yet, some contend that the very power of contraction depends upon nerves. They adduce the influence of poisons, applied to the nerves, in destroying the irritability of muscles to which they are distributed, and declare that, even if strong poison is applied to the nerves of muscles detached from a living animal, the muscles cannot afterwards be excited.[f] But Fontana discovered that the portion only of the nerve that has been in contact with alcohol is incapacitated from conveying stimulus; so that, if the stimulus is applied to the nerve farther on, the muscle contracts as at first.[g] Even had not Fontana made this discovery, the effect could have been ascribed to the transmission only of the effects of the poison along the nerve, and could, like the effect of mechanical and all other irritation of the nerves upon muscles, have shown only the connection and influence between the two. Dr. Whytt discovered that, if an animal is poisoned by opium, the effects pervade the system much

[e] Whytt. *Physiol. Essays.* ed. 2. 1761. p. 249. *Sensibility.*

[f] Dr. Bostock. *Elemen. Syst. of Phys.* ed. 3. p. 179. Dr. Tiedemann, ccccxlii.

[g] This was fully confirmed, in regard to other narcotics, by Dr. C. Henry, *Edinb. Med. and Surgical Journal,* 1832. No. CX. p. 17.

more if the brain and spinal chord are entire, than if they are previously removed: and the inference is clear, that the nerves more readily transmit the effects of the poison than other parts, and not that the muscles lose their excitability through the loss of the nervous influence; because the destruction of the brain and spinal chord has not the effect of poison.[g] Another fact of the same kind is the immediate cessation of the action of the heart or of the intestines by the injection of poison into their cavities, while its application to their external surface operates slowly upon them.[h] Far greater nervous connection must exist between their inner surface than their outer surface and their muscular fibres, because these are destined for stimulation by their contents, and not by matters on the exterior; and thus the effects of poisons will be more readily transmitted by the inner than the outer surface, just like the effects of all stimulating causes. Detached muscles contract under the application of various stimuli of all kinds, and this looks as if their power of contraction is their own. When a detached muscle can be excited no longer, a little rest enables it to become excitable again: and the alternations may be repeated many times. Nay, if a muscle is not detached, but merely all its nerves divided so that its life is preserved, its excitability may be exhausted and recovered for some days.[i] The power continues longer after separation in cold than in warm blooded animals; in voluntary muscles than in the involuntary; and Dr. Whytt discovered, also, that, when an

[g] Whytt himself infers that "opium does not only destroy the moving power of the muscles of animals, by intercepting the influence of the brain and spinal marrow, but also by unfitting the muscular fibres themselves, or the nervous power lodged in them, for performing its office." "It destroys their powers, by means of that sympathy which they have through the brain or spinal marrow, with the nerves to which the opium is immediately applied." *Experiments made with Opium on living and dying Animals.* First published in *Ed. Physical and Literary Essays.* 1755. (r.)

I may remark that he found the nearest part of the nervous system to be the most affected; for, when a solution of opium was inserted into the large intestines, "dogs not only lost the power of motion sooner in their hinder legs than in their fore ones, but also were insensible of any pain in them, and yet howled strongly when their ears were pinched." (m.)

[h] Dr. Munro *Secundus*, and Dr. Wilson Philip; confirmed by Dr. C. Henry, l. c. Still Whytt found opium to poison the whole system sooner if injected into the peritonæum than into the stomach or rectum. l. c. Exp. 21, 22, 23.

[i] *Report of the Fourth Meeting of the British Association.* 1835. p. 671. sqq.

animal is poisoned by opium, the actions of the involuntary muscles of the heart and intestines continue after the voluntary muscles have ceased to contract on the application of the scalpel [k]; the power continues longer in the muscles of the young than of the old; of the well fed than of the ill fed; in warmth than in cold; in atmospheric air and oxygen than in irrespirable gases; and strong stimuli, chemical agents, or narcotics, applied to either muscles or their nerves, rapidly annihilate their powers. [l] Repeated stimulation exhausts a muscle more slowly if its nerves have been divided, because, while the nerves are in connection with it [m], the stimulus affects them also and thus the muscle indirectly as well as directly. If the power of contraction depended on the nerves, the division of the nerves, by cutting off the supply of power, should hasten exhaustion. Vegetables have no nerves, and yet exhibit striking movements. If a muscle, in a mean state of extension, is divided transversely in the living body, the two portions instantly separate; and Bichat found that they separate just as far if its nerves have been previously divided, — another fact in harmony with the opinion of the contractility of muscles being inherent. To ascribe muscular excitability to the nervous system, is but an individual instance of the ascription of the vital properties of all parts to the nervous system, — an opinion which I endeavoured to refute at page 431. sqq. *suprà.* [n] Still the contraction of voluntary muscles is not only excited by nerves at the moment of volition, but preserved constantly to a certain point by the encephalospinal nerves of motion, because, if connection with them is destroyed, or the portion of the encephalon or spinal chord with which they unite is disorganised or compressed, the antagonist muscles, as those of the face, overpower them, or the sphincter of the rectum or bladder is no longer able to retain. Thus in hemiplegia the muscles of the mouth half draw their antagonists

[k] Of course galvanism to their nerves is equally inoperative. Dr. C. Henry, l. c. p. 16.

[l] Dr. Tiedemann, l. c. ccccxlv.

[m] Dr. Wilson Philip, *Exp. Inquiry*, p. 100.

[n] Whytt, in opposition to Haller, contended that the susceptibility of excitement in muscles,— the recognition of stimulus,—depended altogether upon their nerves; and that stimuli excite them by producing an uneasy feeling in them or their nerves. *Essay on the Vital and Involuntary Motions of Animals.* Edinb. 1751.

towards them: in perfect paraplegia, the sphincters of the rectum and bladder no longer retain their respective contents. Some persons, as Cuvier, and since him Dr. Tiedemann, allow excitability to be inherent in muscles, but contend that it is always acted upon through the medium of nerves. It is, however, a mere assumption that, if stimulus can be applied to muscular structure, directly, the presence of nerves is indispensable. Distension acts directly on the muscular fibres; but, with this exception, the functions of muscles are excited intermediately, and therefore through nerves.

The constant tension of muscles is called their tone. After the retraction of the two portions of a divided muscle, these will contract further on stimulation, and relax again to the length they had after retraction. If overstretched, as by a tumour or other cause, muscles lose much of their forced length immediately on the removal of the cause, but may not completely recover for some time; and such shortening is said by Prevost and Dumas not to be accompanied by a zigzag direction of their fibres, though this appears in them as soon as farther contraction is excited by galvanism. If a muscle not overstretched is divided transversely in several places before its life has ceased, each portion necessarily retracts and necessarily grows harder and heavier. When this is done with fish, it is called crimping, and the retraction is, as might be expected, heightened by immersing the portions in cold water. When fish are to be crimped, they are knocked on the head as soon as caught, that they may crimp the better. This impairment of their nervous powers preserves the power of the muscles, which would otherwise be lost in the struggles of the poor animal: but, if the contractility of muscle depended upon nervous energy, it should impair the effects of crimping. This retraction on transverse division takes place only during life or very soon after death, because muscles grow rigid when life has ceased. The latter rigidity is unattended by contraction: it is a mere consolidation, and unfits the fibres for contraction from any cause. Mr. Mayo says that the injection of warm water into the arteries of a muscle induces sudden rigidity.[o] I presume that, like the coagulation of the blood or of albumen, it is a merely chemical change. When death occurs under circumstances which prevent the coagulation of the blood, the rigidity of the muscles is said to be equally prevented.

[o] *Outlines of Human Physiology*, ed. 3. p. 38.

If a muscle has been much distended, it does not contract readily at first. This we notice in the case of the urinary bladder: when the urine has been retained too long it stops, after flowing for a short time; and flows again when the bladder has a little recovered itself. Leeuwenhoek believed that over-distension of the heart might cause sudden death: and he probably was right, for sometimes nothing is seen in cases of sudden death but extreme distension of the right half of the heart, and Professor Coleman, after hanging and drowning animals, found the right auricle and ventricle turgid with blood, and the auricle insusceptible of irritation; but, on opening one of its veins and allowing blood to escape, the application of stimulus in a few minutes induced contraction of the auricle.[p] Pressure upon a muscle facilitates its action. Thus the over-distended bladder, and the uterus after delivery, contract better if the hand is placed over them; and a moderate ligature is often employed by those who are about to make much exertion with particular muscles.

When a muscle is weakened by excessive action, a peculiar unpleasant sensation is experienced, termed fatigue. The weaker the system, the sooner is this sensation experienced. General weakness at the commencement of disease is usually attended by this sensation of weariness, though, when disease is over and mere weakness remains, it is commonly not felt till exertion is made. Distress of mind will bring on this sensation. When a set of muscles is much more exercised than usual, they at first become stiff and painful: but these conditions soon cease, notwithstanding equal exercise is persevered with.

All muscles increase by use; so that, if a man has spent much of his life in some mechanical occupation which requires the action of particular muscles, these are easily distinguished through their disproportionate magnitude. It is thought that the muscular fibres of the urinary bladder increase by exercise more than any others; a continued obstruction to the exit of the urine calls them into such exertion that the inner surface of this organ often resembles that of a cardiac cavity. The heart also frequently grows inordinately from obstruction to the exit of its blood. But this organ, above all other muscular parts, will grow inordinately from mere morbid disposition. In the heart this hypertrophy may produce much distress, if any undue excitement occurs;

[p] *Lectures on the Blood*, by James Wilson, F.R.S. London, 1819.

whereas, in another muscle, the overgrowth may be a matter of no importance. In different persons, different muscles may be better developed and stronger than others: and some persons have their general voluntary muscular system remarkably developed. When this is the case, there is usually a disposition to employ the more powerful parts freely, and thus exercise farther augments them. From the most ancient times some men have performed extraordinary feats of strength. Milo of Crete, after killing an ox with his fist, carried it through the stadium,—a space of 625 feet; and, when the pillar which supported the roof of his master's school gave way, he saved Pythagoras and the scholars from destruction by supporting the roof himself till they escaped. The Jews had their Sampson; and at our shows I have seen a man support a table with many persons upon it and even carry it some little distance between his teeth. Muscular strength appears by Dr. Edwards's experiments to vary at different periods of the day, and to be much affected by diet. By means of the dynamometer he found it increase during the first half of the day, and decrease during the latter; to be instantly increased by a moderate and nutritious meal, except in the weak, in whom the immediate effect of a meal was depression of the strength. Mere water, especially warm, and sugar and water, also instantly diminished the strength. Gelatine, well flavoured with the skin and odorous parts of meat, gave the greatest strength.[q]

The muscles are usually divided into involuntary and voluntary,—those which we have not ordinarily the power of directly contracting, and those which we have ordinarily the power of directly contracting. The action of the heart and all vessels, canals, and cavities, except the outward opening of some, is involuntary: that of most other muscles, voluntary. The mind, however, though not its will, powerfully affects involuntary muscles. Under emotion, the action of the heart may be excited or depressed: any one part may grow turgid and red or shrink and grow pale: and by thinking, voluntarily, of circumstances calculated to excite such emotions, we may voluntarily, in this indirect manner, affect the action of involuntary parts, and even without thinking of circumstances affecting ourselves, but by only dwelling on the circumstances of others,—as in reading. Betterton the actor, when playing Hamlet, could cause

[q] Read in the Academy of Arts and Sciences at Paris, Feb. 11. 1835.

his face at once to become bloodless.[r] Blumenbach says he has seen "some persons able, at any time, to produce a spasmodic horripilation of the skin, by representing some unpleasant object to their imagination. Others have had the power of exciting local sweat in the hands, &c."[s] Strong feelings and a strong power of attention may render many involuntary parts thus indirectly voluntary.[t] Whether strong attention explains the power which some possess over the iris, I do not know.[u] The distribution of its nerves is sometimes unusual, and this may render it directly voluntary. Blumenbach says he once found "the action of the stomach distinctly voluntary in a ruminating man." Unusual distribution of nerves may occur any where just as of arteries: and, if a nerve of voluntary motion should run to a muscle intended to be involuntary, this would become voluntary.[x]

[r] *Penny Cyclopædia.*

[s] "See, for instance, T. Bartholin, *Act. Hafniens.* 1676. vol. iv. p. 191."

[t] "See the *Rapport des Commissaires chargés par le Roi de l'Examen du Magnétisme Animal,* written by J. Sylv. Bailly, a man worthy of a better fate. Paris, 1784. 4to. p. 16."

[u] Belingeri informs us that Mascagni found the iris voluntary in Fontana. *Dissertatio Inauguralis,* P. ii. §. xxi.

[x] Dr. Cheyne, in his *Treatise on Nervous Diseases,* p. 307. sq., relates the following case, which is often adduced as an instance of voluntary power over the heart. If it was, this power had not always existed, nor could it be exerted at once as over voluntary muscles: and probably the mental influence was indirect.

"Colonel Townshend, a gentleman of excellent natural parts, and of great honour and integrity, had for many years been afflicted with a nephritic complaint, attended with constant vomitings, which had made his life painful and miserable. During the whole time of his illness he had observed the strictest regimen, living on the softest vegetables and lightest animal foods, drinking asses' milk daily, even in the camp; and for common drink Bristol water, which, the summer before his death, he had drunk on the spot. But his illness increasing and his strength decaying, he came from Bristol to Bath in a litter, in autumn, and lay at the Bell Inn. Dr. Baynard and I were called to him, and attended him twice a day for about the space of a week, but his vomitings continuing still incessant and obstinate against all remedies, we despaired of his recovery. While he was in this condition, he sent for us early one morning; we waited on him with Mr. Skrine his apothecary; we found his senses clear and his mind calm; his nurse and several servants were about him. He had made his will and settled his affairs. He told us he had sent for us to give him some account of an odd sensation he had for some time observed and felt in himself, which was, that composing himself, he could die or expire when he pleased, and yet by an effort, or somehow, he could come to life again; which it

On the other hand, there is no voluntary muscle that may not act involuntarily. If the motive to contract a muscle is very

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seems he had sometimes tried before he had sent for us. We heard this with surprise; but as it was not to be accounted for from now common principles, we could hardly believe the fact as he related it, much less give any account of it, unless he should please to make the experiment before us, which we were unwilling he should do, lest in his weak condition he might carry it too far. He continued to talk very distinctly and sensibly above a quarter of an hour about this (to him) surprising sensation, and insisted so much on our seeing the trial made, that we were at last forced to comply. We all three felt his pulse first: it was distinct, though small and thready, and his heart had its usual beating. He composed himself on his back, and lay in a still posture some time; while I held his right hand, Dr. Baynard laid his hand on his heart, and Mr. Skrine held a clean looking-glass to his mouth. I found his pulse sink gradually, till at last I could not feel any by the most exact and nice touch. Dr. Baynard could not feel the least motion of his heart, nor Mr. Skrine the least soil of breath on the bright mirror he held to his mouth; then each of us by turns examined his arm, heart, and breath, but could not by the nicest scrutiny discover the least symptom of life in him. We reasoned a long time about this odd appearance as well as we could, and all of us judging it inexplicable and unaccountable; and finding he still continued in that condition, we began to conclude that he had indeed carried the experiment too far, and at last were satisfied he was actually dead, and were just ready to leave him. This continued about half an hour, by nine o'clock in the morning, in autumn. As we were going away, we observed some motion about the body, and upon examination, found his pulse and the motion of his heart gradually returning: he began to breathe gently, and speak softly: we were all astonished to the last degree at this unexpected change, and after some further conversation with him and among ourselves, went away fully satisfied as to all the particulars of this fact, but confounded and puzzled, and not able to form any rational scheme that might account for it. He afterwards called for his attorney, added a codicil to his will, settled legacies on his servants, received the sacrament, and calmly and composedly expired about five or six o'clock that evening. Next day he was opened (as he had ordered): his body was the soundest and best made I had ever seen; his lungs were fair, large, and sound; his heart big and strong, and his intestines sweet and clean; his stomach was of a due proportion, the coats sound and thick, and the villous membrane quite entire. But when we came to examine the kidneys, though the left was perfectly sound and of a just size, the right was about four times as big, distended like a blown bladder, and yielding as if full of pap; he having often passed a wheyish liquor after his urine, during his illness. Upon opening this kidney, we found it quite full of a white chalky matter, like plaster of Paris, and all the fleshy substance dissolved and worn away, by what I called a nephritic cancer. This had been the source of all his misery; and the symptomatic vomitings from the irritation on the consentient nerves, had quite starved and worn him down. I have narrated the facts, as I

strong, we may not be able to refrain from willing its contraction; just as a very strong motive may involuntarily impel us to will any mental operation. If you cause strong pain or titillation in a person, he will be compelled, whatever restraint he may attempt upon himself, to cry out or laugh, and to make an effort to remove it by motion of some part. We are instinctively and almost unconsciously led to will suitable motions, and if, as usually is the case, we have no motive not to yield to the inclination, the motion takes place almost without the appearance of our will. It is thus that we breathe and wink all day. The respiratory muscles deserve the epithet voluntary as much as any in the body, for we directly contract them[y]: we feel an uneasy sensation in the chest from the retardation which occurs to the blood, and we inspire to remove it; the uneasiness being removed, our effort ceases, and expiration spontaneously ensues. The necessity for sighing after reading or listening attentively arises from our having forgotten to breathe fully,— not having fully perceived the want of breath while our attention was so occupied[z]; and the general coughing and sneezing in church at a pause in the sermon are owing to the sensations which give rise to those actions having been for a time overpowered throughout the congregation by other feelings.[a] It is true that respiration continues while we are asleep, and that the uneasiness is so great that we are forced to inspire.[b] But the same is true of all voluntary muscles.

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saw and observed them, deliberately and distinctly, and shall leave to the philosophic reader to make what inferences he thinks fit; the truth of the material circumstances I will warrant."

M. Ribes is said to have published a similar case: but I have not been able to find it.

[y] This is the opinion of Haller, and ably defended by him. *El. Physiol.* t. iii. lib. viii. § 18.

[z] Dr. Darwin, *Zoonomia*, vol. i.

[a] Dr. Alison's Observations on Sympathy in the *Edinburgh Med. Chirurg. Trans.* vol. ii.

[b] Opposite circumstances have an opposite effect. When the French soldiers drove the Piedmontese on the tops of the Alps between St. Bernard and Cenis, Parat and Martin say that the mouth and nose were involuntarily closed against the storm,— that all attempts at inspiration were fruitless, and, if they could not oppose the blast by turning round or putting the hand to the mouth, they fell down giddy and died. (*Mém. de la Soc. Méd. de Lyons.* 1798.)

First as to the continuance of respiration during sleep. If you irritate any part of a person asleep, an effort of some kind is made to withdraw from the source of uneasiness, and people turn in their sleep when uncomfortable; fowls perch on one leg, voluntarily contracting their claws before they go to sleep, and remain thus supported till they awake, though the bent condition of the claw is much preserved by mere mechanism. But men will sleep standing: somnambulists unconsciously perform astonishing muscular movements: and, while awake, we continue winking, coughing, and often continue walking, or performing other voluntary actions, while our minds are totally absorbed in reflecting and give no perceptible attention to our corporeal movements; a person will play even a rapid piece of music, familiar to him, while thinking and perhaps talking of something else, and forgetting that he is at the instrument, though originally each of the infinite number of volitions requisite to the performance may have been slow and laborious [c]: nay, a person may fall asleep after beginning a very habitual set of actions, and continue them,

[c] Dr. Whytt confounded mind and life, and, believing that they were an immaterial substance, and matter incapable of vital and mental properties or soul, ascribed all the functions of animal bodies, human and brute, to a soul diffused through every part. (*Of the Vital and Involuntary Motions of Animals.* 1751. sect. xi. obj. i.) But, notwithstanding this prejudice and hypothesis, he shows that volition may be exerted without consciousness. "Many of the voluntary motions are performed," he says, "when we are insensible of the power of the will excited in their production. Thus, while in walking, we either meditate by ourselves, or converse with others, we move the muscles of our legs and thighs, without attending to it or knowing what we are doing. We are not sensible of the eye-lids being kept open by the continued operation of the will; but yet, when drowsiness and sleep steal upon us, we find it requires a considerable effort to prevent the falling down of the superior palpebræ. The same thing is known of the muscles which support the head. The most probable account of our ignorance of these things seems to be this; — namely, that we not only acquire, through habit, a faculty of performing certain motions with greater ease than at first, but also, in proportion as this facility is increased, we become less sensible of any share or concern the mind has in them. Thus a young player upon the harpsichord, or a dancer, is, at first, solicitous about every motion of his fingers, or every step he makes, while the proficients or masters in these arts, perform the very same motions, not only more dexterously, but almost without any reflection or attention to what they are about. (Ib. obj. iii.)

Mr. Dugald Stewart's chapter on attention (*Elements of the Philosophy of the Human Mind.* 1792. ch. ii.) well deserves perusal, though published forty-one years after Dr. Whytt's Essay.

as we have seen in the instance of poor little children, who, when dead asleep, were observed still to move their fingers as if at

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"In the case of some operations which are very familiar to us, we find ourselves unable to attend to, or to recollect, the acts of the will by which they were preceded; and accordingly, some philosophers of great eminence have called in question the existence of such volitions; and have represented our habitual actions as involuntary and mechanical. But surely the circumstance of our inability to recollect our volitions, does not authorise us to dispute their possibility; any more than our inability to attend to the process of the mind, in estimating the distance of an object from the eye, authorises us to affirm that the perception is instantaneous. Nor does it add any force to the objection to urge, that there are instances in which we find it difficult, or perhaps impossible, to check our habitual actions by a contrary volition. For it must be remembered, that this contrary volition does not remain with us steadily during the whole operation; but is merely a general intention or resolution, which is banished from the mind, as soon as the occasion presents itself, with which the habitual train of our thoughts and volitions is associated.

"It may indeed be said, that these observations only prove the possibility that our habitual actions may be voluntary. But if this be admitted, nothing more can well be required; for surely, if these phenomena are clearly explicable from the known and acknowledged laws of the human mind, it would be unphilosophical to devise a new principle, on purpose to account for them. The doctrine, therefore, which I have laid down with respect to the nature of habits, is by no means founded on hypothesis, as has been objected to me by some of my friends; but, on the contrary, the charge of hypothesis falls on those who attempt to explain them, by saying that they are *mechanical* or *automatic;* a doctrine which, if it is at all intelligible, must be understood as implying the existence of some law of our constitution, which has been hitherto unobserved by philosophers; and to which, I believe, it will be difficult to find any thing analogous in our constitution."

"I cannot help thinking it more philosophical to suppose, that those actions which are originally voluntary, always continue so; although, in the case of operations which are become habitual in consequence of long practice, we may not be able to recollect every differect volition. Thus, in the case of a performer on the harpsichord, I apprehend, that there is an act of the will preceding every motion of every finger, although he may not be able to recollect these volitions afterwards; and although he may, during the time of his performance, be employed in carrying on a separate train of thought. For, it must be remarked that the most rapid performer can, when he pleases, play so slowly, as to be able to attend to, and to recollect, every separate act of his will in the various movements of his fingers; and he can gradually accelerate the rate of his execution, till he is unable to recollect these acts. Now, in this instance, one of two suppositions must be made: the one is, that the operations in the two cases are carried on precisely in the same manner, and differ only in the degree of rapidity; and that when this rapidity exceeds a certain rate, the acts of the will are too

work after the machinery had all stopped. (*suprà*, p. 460.) There is nothing surprising in this, if we consider the counterpart in regard to sensation. For that, on the other hand, we may have sensations and not be aware of them, is shown by persons falling asleep at church and remaining so during the sermon, but awaking as soon as the preacher's voice is silent. The effect of the cessation of the stimulus shows that the stimulus was all along felt.—These facts are true of all voluntary muscles: and so likewise are those of the facility of action where there is no habit but an instinctive impulse to will certain motions. In one sense all voluntary motions are instinctive: that is as far as men and brutes know nothing of their muscles, and do not determine upon contraction of these fibres or those, or of this combination of muscles or that, or upon the amount of contraction in each respective muscle, but upon such a movement as they choose of a

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momentary to leave any impression on the memory. — The other is, that when the rapidity exceeds a certain rate, the operation is taken entirely out of our hands; and is carried on by some unknown power, of the nature of which we are as ignorant, as of the cause of the circulation of the blood, or of the motion of the intestines. The last supposition seems to me to be somewhat similar to that of a man who should maintain, that, although a body projected with a moderate velocity, is seen to pass through all the intermediate spaces in moving from one place to another, yet we are not entitled to conclude, that this happens when the body moves so quickly as to become invisible to the eye. The former supposition is supported by the analogy of many other facts in our constitution. Of some of these, I have already taken notice; and it would be easy to add to the number. — An expert accountant, for example, can sum up, almost with a single glance of his eye, a long column of figures. He can tell the sum, with unerring certainty; while, at the same time, he is unable to recollect any one of the figures of which that sum is composed; and yet nobody doubts, that each of these figures has passed through his mind, or supposes, that when the rapidity of the process becomes so great that he is unable to recollect the various steps of it, he obtains the result by a sort of inspiration."

The rapidity of the volitions can afford no objection. "A person playing on the harp, dancing, and singing, at the same time, exercises about three hundred muscles at once. (G. Ent, *Animadv. in* Thrustoni *diatribam*, p. 130.)" In speaking, fifteen hundred letters may be distinctly pronounced in a minute, each requiring a separate volition. The rapidity of thought is still quicker. Rapidity, like minuteness, is only relative to what we commonly witness. An animal millions of times smaller than the minutest known microscopic creature might have as great a complexity of parts as ourselves; movement might be millions of times swifter than any thing we ever observed.

moveable part. In another sense all voluntary motions are instinctive, because, on the occurrence of certain wishes, of a certain strength, we perform certain motions: a person who dances, dances because his wish is at a certain height; a man who makes a machine, cuts and arranges its parts through the same cause. But some sensations, some states, cause us and brutes to will certain motions without habit or experience; and yet the occurrence of will is just as clear. The teat in the young animal's mouth causes it directly it is born to will suction. The only difference in this case is one of time: the particular sensation or state is, without habit or circuitous circumstances, at once followed by the action. To depress the head, when passing on the top of a coach under a low arch, is just as instinctive: and the action of any muscle may be so willed, or any combination of muscles.

Secondly as to our being forced to inspire. If you cause strong pain or titillation in a person, he will be compelled, whatever restraint he may attempt upon himself, to cry out or laugh, and to make an effort to remove it by motion of some part, quite as forcibly as he is compelled to remove the uneasiness in the chest by inspiration; and while history records innumerable examples of persons, whether Christians or heathens, so resolute as to remain motionless and silent, by the force of their faith or innocence or their contempt for their persecutors[d], in the midst of fire till they were consumed, and we ourselves know the resolution of Hindoo widows every day to perish on the funeral pile of their husbands, we read of suicides so determined as to have accomplished their purpose by merely holding their breath, when deprived of access to instruments of destruction.[e] Thus, though some have regarded the muscles of

[d] See Lord Bacon, *De Augmentis Scientiarum*, l. iv. cap. 1. Among other instances of resolution he mentions that, in his day, a murderer of Burgundy, "when beaten with iron rods and torn with red-hot pincers, did not utter a groan, and, seeing something break and fall accidentally on the head of a bystander, the rascal laughed in the midst of his torments while being burnt, though he had just before cried at having his curly hair cut off."

[e] "Servus barbarus, cum vehementi irâ concitatus, mortem sibi consciscere decrevisset, prostratus humi, respirationeque cohibitâ, longo tempore immobilis erat; postea verò paululum volutatus, hoc pacto mortuus est." (Galen, *De Nat. Musc.* lib. ii. c. 6.)

A robber named Coma, when taken before the consul Rupilius, is said by

respiration as of a mixed character, as both voluntary and involuntary, they appear to me as voluntary as any voluntary muscles; but equally, though not more, liable to become involuntary. The orbicularis palpebrarum all allow to be a voluntary muscle; yet, if a person suddenly moves his finger towards one of our eyes, even without touching it, we wink involuntarily. Nay, without such motives, some voluntary muscles are in certain circumstances involuntary. We move our ring finger at pleasure; yet if we bend our little finger, few can refrain from bending the ring finger. We experience great difficulty "in attempting to move the hand and foot of the *same* side in *different* directions, and in all those motions which, although voluntary and perfectly easy if produced separately, are found very difficult if attempted together."[f] Again, "few voluntary motions may not be rendered involuntary by the force of habit, whose influence upon the mind is immense." Every action of the system, mental or corporeal, takes place more readily in proportion to its repetition; and therefore certain actions of voluntary muscles may at length occur not only with an almost imperceptible exciting cause, but in doing an action we may from habit be unable to perform it except in one way, and actions of

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Valerius Maximus to have so destroyed himself. "Let others," says the historian, "sharpen the sword, mix the poison, take the rope, look for precipices,"—"nihil horum Coma, sed intra pectus inclusa anima, finem sui reperit." (Lib. ix. cap. xii. externa. 1.)

Few can have so much determination; and, indeed, success can rarely follow this attempt at suicide, because, as soon as the brain begins to suffer, the effort must decline, and the effects cease. Still, from general or partial tenuity of the vessels of the head, such congestion may readily occur as may occasion rupture; and suicide of this kind is therefore by no means impossible. I have known the sinuses rupture under strong muscular exertions.

Dr. Georget mentions that a M. Bourdon made some experiments upon himself, from which it appeared that a person may commit this kind of suicide. (*De la Physiologie du Système Nerveux, &c.*, t. i. p. 387.)

It is said that suicide has frequently been committed by turning the tongue back, and thus excluding the air from the larynx. In *Notices of Brazil, in* 1828–9, the Rev. R. Walsh says that the poor wretched slaves often destroy themselves thus. "A friend of mine," he adds, "was passing when a slave was tied up and flogged; after a few lashes he hung his head, appearing lifeless, and when taken down, was actually dead; his tongue was found wedged in the œsophagus.

[f] "Consult Winslow, *Mém. de l'Acad. des Sciences de Paris.* 1739."

voluntary muscles in which we have indulged may be performed against our wishes in particular circumstances.

Between the portion of the brain that wills and the muscle, an intermediate portion of the nervous system exists. The will is not exerted upon the muscles, but upon the motor nerves of muscles at their extremity in the brain or spinal chord. Now this extremity or the nerve in any part of its course may be stimulated by other causes than the will, and thus the muscles ordinarily stimulated by the will may be stimulated without it, —the will may neither voluntarily nor involuntarily have a share in stimulating the muscles. Thus it is in chorea[g], tetanus, and other spasmodic diseases of the voluntary muscles. Even in palsy of motion, we often observe spasms, especially in paraplegia. Now, when a motion is naturally willed in consequence of a sensation in a particular part, a peculiar relation exists between the nerves of sensation of that part and its nerves of motion, so that irritation of the former is communicated to the latter. Thus at page 420. we saw that in 1788 Sir Gilbert Blane found the hind legs of a decapitated kitten retract if the paws were touched with a hot wire, and the tail move if so touched after division of the chord below the last lumbar vertebra. In cold blooded animals similar observations had long before been made. Redi in 1687[h] found in a large tortoise, which lived twenty-three days after losing its head, that the fore and hind feet were forcibly convulsed whenever they were pricked. Whytt, in 1745, found that, if the toes of both feet of a decapitated frog are stimulated, the feet are drawn up

[g] The exciting cause that influences the nervous system beyond the cerebral part which wills may be opposed, and temporarily with success, by the will; and on the other hand the will may aid the exciting cause. So that under chorea persons can frequently arrest the motions for a few seconds, or run when they cannot walk; and, again, they often seem to feel a pleasure in co-operating to produce the morbid movements.

[h] I mentioned, *suprà*, p. 421., that, above a century and a half ago, Duverney found a bird would move after losing its brain; Dr. Kaau, in 1745, observed a frog move all its limbs for half an hour after decapitation, and for a considerable time after its body was divided in two. A viper, after losing its head and bowels, moved towards a heap of stones where it had been accustomed to hide itself. (*Impetum faciens*, No. 331.) Redi extracted the brain of a land tortoise through a hole in the skull, and it lived from November to May, moving and walking about to the last. (*Osservazioni intorno agli animali viventi, &c.* Napoli. 1687. p. 209. sq. Butterflies copulate and lay eggs after decapitation.

to the body; or, if one foot only, that foot only is drawn up.[i] He also found that, if the muscles of the leg of a decapitated frog are irritated, almost all the muscles of the lower extremities move, provided the spinal chord is entire; but, if the chord is destroyed, the neighbouring muscles remain still, and the irritated muscle itself is only excited to a tremulous motion.[k] He also noticed that, though the muscles of the thighs were contracted when pricked or cut, neither they nor the neighbouring muscles were nearly so strongly convulsed as when the toes were wounded, — the toes having a much more acute sensibility.

Others have since variously illustrated these facts. Dr. Magendie mentions that, when the posterior roots of the inner side of the spinal nerves are irritated, the signs of extreme pain are accompanied by convulsions of the muscle of that same side only: Mr. Mayo, that, if the head of a pigeon is cut off and all the brain removed except the little to which the common motor nerve of the eye is attached, and the optic nerve divided and its truncated extremity connected with the brain pinched, the iris instantly contracts: Dr. Macartney, that, if the head of a pigeon is cut off, nay, if even the eye is taken out, light suddenly admitted to the retina produces contraction of the iris.

These facts have lately given rise to a speculation that a portion of the nervous system exists independent of will, and solely for involuntary actions of what are usually considered voluntary muscles, by means of impressions, not felt, on nerves usually considered nerves of sensation. A portion of the chorda oblongata and of the chorda spinalis is fancied to be separate and independent of the rest, and this imaginary part is called by its inventor,—Dr. Marshal Hall[l], *excito-motory*. This physician has made experiments fundamentally the same as those of Sir Gilbert Blane and his successors. Instead of separating a portion of the body with its corresponding portion of encephalo-spinal substance in which the nerves of sensation and motion meet, he only stupefied an animal. He struck a horse with a pole-axe over the anterior lobes of the brain. It fell as if thunderstruck; was convulsed, and then motionless. But it soon began to breathe, and continued to breathe freely. When

[i] *Observations on Irritability*, sect iv. p. 4. [k] Ibid.

[l] *Phil. Trans.* 1833. P. ii.; and *Lectures on the Nervous System.* 1836.

lacerated or pricked by a pin or nail on any part of the face or rest of the surface, it was still motionless, and gave no evidence of impression. But on touching the eyelash with a straw, the eye forcibly closed; on touching the cornea, the eye rolled outwards; and on touching the verge of the anus, the sphincter contracted, the tail was raised, and the vulva drawn towards the anus. Now this only shows what is well known, that tickling certain exquisitely sensible parts with a straw induces a stronger impression than rough usage with a nail or pin. A person who could bear pain without flinching, could not remain still under tickling of certain parts: and yet it is only certain parts that are so ticklish. The sensible ends of the fingers or the back of the hand may be touched with a straw in vain. Dr. M. Hall himself shows that a strong impression made any where would equally excite motion. For he goes on to repeat the very experiment of Sir Gilbert Blane. He divided the spinal chord of a frog below the occiput. The animal was still. He *pinched*, not tickled, a toe with a pair of forceps. Both hind extremities moved. He pinched again, and the motions recurred. Now this was not an eyelash, the cornea, or verge of the anus, but some other part of the surface, and it might of course have been any sensible part, and the corresponding muscles of the part would have acted. If a correspondently strong impression had been made in the horse, motion would have equally taken place. Surely, when we wink on the eyelash being touched, we do this by precisely the same operation as when we withdraw a hand that is struck. Of course, when the spinal chord is destroyed, or any portion of the encephalon is destroyed in which are the extremities of the nerves of sensation that convey the impression, or the extremities of the nerves of motion that convey the stimulus to the muscles, or in which they meet, as they probably do, no effect from pricking or tickling, &c. can ensue. Dr. M. Hall considers that the excitor nerves of the excito-motory system are the ganglionic portion of the fifth and of each spinal nerve, and the pneumono-gastric; the motor nerves of it, the aganglionic portion of the fifth and of each of the spinal nerves; the fourth, sixth, seventh, and ninth encephalic, the pneumono-gastric and its pharyngeal and laryngeal branches, the spinal accessory, the phrenic, and Sir C. Bell's external respiratory.

Now really the whole truth appears to be what is well known,

that an impression made upon *any* nerve of sensation, or, what is the same thing, upon *any* part endowed with sensibility, may induce action of *any* voluntary muscles calculated to remove it, if disagreeable, or to be useful in some way to the individual, even though the brain be prevented from perceiving the impression, — from having a sensation from the impression. The impression need not be upon nerves running to the part of the encephalo-spinal organs where the roots lie of the motor nerves excited, for a sharp pinch of the toe will make a man not merely draw away his foot, but raise his arms, make a face and halloa into the bargain, whether he is asleep or awake. Tickling the sentient twigs of the fifth pair, the eyelid, and cornea, is not requisite to cause winking; if by the optic nerve, one not included in Dr. M. Hall's excito-motory class, we see a finger suddenly approach the eye, instinctive, involuntary winking will as certainly occur. Winking will occur if a strong light is suddenly admitted through the lids to the *retina* of a person asleep. The sun's glare upon the retina will excite sneezing.[m] Not only are sneezing, vomiting, sobbing, mentioned as acts of this system, but even deglutition, which is declared *always* to be of this nature, and always to require the presence of some stimulus to the sensible nerves of the pharynx, it being "impossible to perform the act of swallowing three or four times in rapid succession, without taking something into the mouth." Now if deglutition is always an *excited* act,—to use this gentleman's peculiar language,—is always produced involuntarily by an impression on the pharynx, it must be as impossible once or twice, without taking something into the mouth, as three or four times, and slowly as rapidly. I, however, can swallow with nothing in my mouth in rapid succession, as readily as with something, and above fifty times; that to say, till the muscles are fatigued. If swallowing is instinctive when any thing reaches the pharynx, so is the act of opening the mouth when a sugar-plum is offered to the eyes of a baby: and

[m] Just as Dr. Fletcher considered the respiratory function of Sir C. Bell's imaginary respiratory system of nerves, as only a part of its functions, its destination being for sympathy at large, as well as for the sympathetic respiratory movements, Dr. M. Hall considers Sir C. Bell's respiratory system of nerves as only a part of his own peculiar excito-motory system, which presides over respiration as well as other excito-motory functions. The views of all these gentlemen appear to me equally confined and erroneous.

indeed the various movements of the extremities, head, and trunk, which naturally are performed on various circumstances presenting themselves, are just as instinctive; and we have only to observe the movements of other animals, especially of those most like ourselves, and above all of monkeys, to see how instinctive our voluntary actions are, when we are most apt to regard them as determined by our reflection. We contract all voluntary muscles either simply because we think proper, as when we cough at the request of another, or because a strong motive is given, as when we withdraw the hand from any thing hot; and the latter is only such an instance as swallowing, coughing, winking, &c. when food is in the pharynx, phlegm in the larynx, or strong light in the eyes. Certain sensations excite a certain desire, and this may be too strong for us to overcome. But according to the strength of mind will be the resistance to the strength of the desire induced by the sensation. Some actions result from certain sensations only, and we can neither perform some without these sensations, nor when these sensations exist find it possible not to yield to the desire. With some deglutition is not an act of this kind. But sneezing is with all. I never knew a person able to sneeze at pleasure. To be induced to will sneezing we must have a certain sensation. If our attention is drawn to something else, though the irritating cause act, we do not feel the sensation, and do not sneeze. If the sensation is felt forcibly, the impulse may be too strong for us to resist, and sneezing will be involuntary: and we can bring ourselves to sneeze by attending closely to the sensation, and by increasing it. I have often amused myself by looking more or less at the sun, or thinking more or less of tickling felt at the moment in the nostrils, and so increasing and lessening the inclination to sneeze. Without the *sensation*, and a certain amount of it, the sneezing no more than venereal convulsion of the ejaculatores takes place. At the same time, the facts discovered by Sir Gilbert Blane and others show a connection between motion and impression independent of the brain. But this is probably intended to assist the will in exciting motions on the occurrence of impressions on individual parts; and the impression may be so strong that the will may be compelled to determine the motion, and this compulsion will be according to the strength of the impression and the weakness of opposing motives and of the resolution to resist the inclination. Nay, these

facts show that motion will occur when the brain is removed and there can be no sensation. Yet when the brain exists and in healthy force, that the will does co-operate with this local excitement of nerves of voluntary motion by those of sensation, when we might not be disposed to believe it, appears from the curious facts mentioned at pages 486–491. showing that sensations may occur, and the will may be exercised, almost unconsciously. While the brain exists and the system is in health, these motions do not occur without will, or without sensation should the will be overpowered.

Involuntary muscles have generally a faint red colour, tolerable firmness, fibres small and rather interwoven together, blood-vessels and nerves comparatively numerous and small, and seldom a tendon: while voluntary muscles have generally a deep colour, comparatively soft consistence, their apparent fibres large and generally parallel, comparatively few and large blood-vessels and nerves, and commonly a tendon.[n]

Involuntary muscles are said not to contract suddenly on division, and to perform not one sudden but several contractions, when stimulated; whereas voluntary muscles, when divided or stimulated, contract suddenly.

Involuntary muscles are said to have more nerves proportionately than the voluntary.

Like all other parts, muscles require a supply of arterial blood; and this is proportionate not only to the bulk of a muscle, but to the force and duration of its action. If venous blood is sent to the brain, we have seen that death ensues, and the function of any part is arrested by forcing venous blood into its arteries[o]: this not only not supplying the place of arterial blood, but acting as a poison. Muscles, however, retain their excitability after their supply of arterial blood is cut off, as when they are separated from the body. " In the Stenomian[p] experiment, paralysis of the hind legs commonly follows the application of a ligature upon the abdominal aorta." But this does not show the excitability of the muscles to be impaired; they would doubtless contract immediately after the experiment, upon the appli-

[n] Dr. Fletcher, l. c. P. 1. p. 109.

[o] Bichat, *Recherches Physiologiques.*

[p] " Steno. *Elementar. Myologiæ Spec.* Florent. 1667. 4to. p. 86."

cation of a stimulus, as readily as they do after apoplexy, and after removal of the brain or division of their nerves. In torpid brutes, after division of the nerves and removal of the brain, cold and warmth destroy and restore the excitability of muscles, as usual. The ligatures act immediately by depriving the nerves of the power of stimulating them; for a constant supply of arterial blood is necessary to the functions of the nervous system[q], and the ligature of the abdominal aorta, repeated by Courten and Haller[r], cuts off this from the lower part of the spinal chord and what originate from it, — the nerves of the hind legs.[s] Another source of loss of motion must ultimately arise, — the loss of excitability and vitality from the want of circulation in the muscle.

In regard to its composition, muscle is said to be essentially fibrine, but to contain also albumen, gelatine, lactic acid, fat, salts, &c. and a substance termed osmazome, upon which the peculiar taste and smell of soup depends, and which is a yellowish brown substance, soluble in water and in alcohol hot or cold, and not forming a jelly when concentrated.

Raspail properly points out that muscle has thus been analysed on the large scale, with its blood-vessels, lymphatics, nerves, and fatty cellular membrane; but that the analysis should have been limited to the muscular cylinder. Gelatine is produced from cellular texture, skin, tendons, ligaments, cartilages, and bones by boiling only: osmazome by boiling from muscle, serum, and mushrooms, and, according to him, is only an impure compound of albumen and acetic acid: lactic acid he declares to be merely acetic acid and albumen: and leucine, a white matter obtained from muscle by Braconnot through the means of sulphuric acid, to be only a mixture of oil, and even albumen rendered soluble by an acid, with sulphite of ammonia. By repeatedly boiling muscle, and holding it in the air between each boiling, Berthollet found it at last acquire the smell and taste of old cheese. The

[q] Le Gallois, *Sur le Principe de la Vie.*

[r] "W. Courten, *Phil. Trans.* No. 335. p. 500." 1678.

"Haller, *Comment. Soc. Sc. Gotting.* t. iv. p. 293." 1754.

[s] Sir Astley Cooper has just published the result of obstructing the vertebral arteries which supply those parts of the spinal chord from which the nerves chiefly concerned in respiration arise. Dyspnœa instantly ensued. (*Guy's Hospital Reports,* No. iii.)

same are perceptible in dried anatomical preparations; and Raspail by repeated boiling effected them in fecula, converting it into caseic acid. If fresh muscle is exposed for some time to water, or kept in moist earth, the fibrine disappears, and a white fatty matter remains called adipocire: but this is usually ascribed to a change of the fat in the muscle. Muscle may perhaps be changed during life into fat, for we possess in University College diseased muscles, in which each fibre is replaced by a string of fat. Fibrine abounds most in the muscles of the old.

Besides the vital movements which probably occur in the vessels and cellular texture of plants, and those which occur slowly in the stalks and tendrils of annuals which cling, and in leaves, we observe the flowers and leaves of many plants stand up open in the day and fall or close at night. On the approach of a storm, the leaves of most plants with delicate stamina become erect, so that white flowered meadow trefoil is a barometer to the Swedes. Artificial light will make the flowers and leaves of some plants expand at night, and removal to a dark place in the day time make them droop; while the approach of hot iron to their upper surface will make some leaves erect. Cold and narcotics lessen or destroy, while all stimuli augment, these movements, which are more vigorous in the young than in the old. Even mechanical irritation, perhaps a mere touch, will cause motions in the leaves of mimosæ; and the motion will spread from the one irritated to other leaves successively, and the petiole, and at last the foot-stalk itself, descends. The lobes of the leaves of the dionæa muscipula have stiff hairs on their edge, and close instantly upon a hapless insect which lights upon them; and, as each lobe of the leaf has three thorns, the poor thing is not only imprisoned but impaled on the spot: and, what is still more cruel and corresponds in design with the craftiness of animals, as that does with their destructiveness, the leaf is supplied with glands which secrete sugar and thus tempt the instinct of the poor thing. The small lateral leaves of the hedysarum gyrans and cuspidatum are in incessant motion. Some flowers contract on mechanical irritation. The stamina and pistils of flowers, but especially the stamina, perform many varieties of motion, and also obey external stimuli, and are influenced by poisons.*

The voluntary motions are the distinguishing characteristics of the animal from the vegetable kingdom. For no plant has been discovered procuring for itself food by means of voluntary motion; nor any animal incapable of locomotion, or at least of procuring sustenance by the voluntary motion of individual members.

Muscles exist in animals of all classes, from the mammifera to the radiaria.

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* Consult Dr. Tiedemann, l. c. cccclxxiii. sqq.

They have been discovered in agreat number of entozoa. Even in the actiniæ, some medusæ, and other zoophyta, muscular fasciculi, interwoven with the external skin, have been perceived; and Professor Ehrenberg has detected them in the infusoria.* Their fibres are not always red, but may be white, or yellowish.

Minute and numerous hair-like processes, called *cilia*, are observed on the external surface of batrachian larvæ, of mollusca, annelida, echinodermata, actiniæ, medusæ, polypi, and infusoria; on the surface of the air passages of man and other mammalia, birds and reptiles, as well as on the external gills of batrachian larvæ, and on the gills of mollusca and annelida; in other annelida, and in echinodermata and actiniæ, on the membrane of the external surface of the viscera and its parietal portion to which water has access; on the surface of the mouth and gullet of reptiles, and more or less on the whole of the rest of the alimentary canal of mollusca, actiniæ, annelida, echinodermata, and polypi; in the pores and canals of sponges; on the mucous membrane of the Fallopian tubes, uterus and vagina of mammalia and fish, as well as on the organ of smell in the latter, and the oviduct of birds and reptiles; on the surface of the embryo of batrachia, mollusca, actiniæ, polypi, and sponges. The longest cilia hitherto measured have proved ·005 of an inch, the smallest ·000075 of an inch. The motion of each cilium is commonly of a fanning character, though sometimes it is rotatory, or, as the point revolves the most extensively, infundibuli-form; and separation of the part, and even death, does not arrest it for a few hours in mammalia and birds, nor for upwards of a fortnight in the tortoise and river mussel, — differences corresponding with the varied duration of muscular contractility in the same animals. The purpose of this vibration is to carry the animal through the fluid in which it lives, or to drive fluids along its surfaces. For a full account of the cilia, see a paper by my no less excellent than able colleague Dr. Sharpey, in Dr. Todd's Cyclopædia of *Anatomy and Physiology* Very recently Purkinje has discovered them on the linings of the cerebral cavities of the fœtuses of some mammalia. Müller's *Archiv für Anatomie, Physiologie*, &c. No. 1. 1836. p. 291. sq.

Sometimes, as in crustacea and insects, they are situated in hollow, calcareous or horny parts; sometimes in earthy shells, as in bivalve and multivalve mollusca.

A writer says that he "repeatedly placed a common dorr," the occupation of which beetle is to heave up the earth, "under a weight equal to 4796 grains, 319 times its own weight," the animal being but 15 grains, and the creature "heaved it up and withdrew; and the same pressure, being placed on its leg, was immediately disengaged by the power of the other." (*Journal of a Naturalist*, p. 305.)

Muscular power is no where more displayed than in some fish. "I have seen," says Sir Gilbert Blane, "the sword of a swordfish sticking in a plank

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* See Dr. Gardiner's account of Professor Ehrenberg's discoveries in the *Edin. New Phil. Journ.* 1831.

which it had penetrated from side to side; and when it is considered that the animal was then moving through a medium even a thousand times more dense than that through which a bird cleaves its course at different heights of the atmosphere, and that this was performed in the same direction with the ship, what a conception do we form of this display of muscular power!" (*On Muscular Motion. Select Dissertations*, p. 281.) Muscular strength is proportionally much greater in smaller animals. "A flea can draw from seventy to eighty times its own weight, whereas a horse cannot draw with ease more than three times its own weight." (l. c. Haller, *El. Physiol.* L. ix. S. iii.)

A flea weighs less than a grain, and will clear an inch and a half at a leap; and Americans have calculated that if a man, weighing about 150 pounds, could leap in proportion, he would be able to spring 12,800 miles, and so jump with ease from New York to Cochin China.

In some animals of very slow motion, as the tardipedes, the chief artery of the extremities is found split into many parallel trunks, instead of remaining as one and branching forth. (Sir Anthony Carlisle, *Phil. Trans.* 1810.) In the fore leg of the lemur tardigradus, sixty brachial arteries exist. The connection between this circumstance and slow motion is unknown.

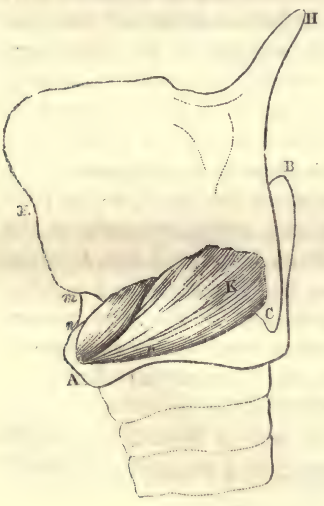
CHAP. XXI.

VOICE AND SPEECH.

An important operation of muscular motion is in producing sounds by means of those parts through which the air passes in respiration.

The vocal mechanism may be considered as consisting of lungs, or bellows, capable of transmitting, by means of the connecting windpipe, or trachea, a current of air passing through an apparatus called the larynx, which is placed on the upper part of the windpipe. This apparatus, though of very small dimensions, is capable of producing sounds in great variation of pitch, quality, and intensity, which are afterwards converted into the articulations of speech by passing through a cavity consisting of the pharynx, mouth, and nose.

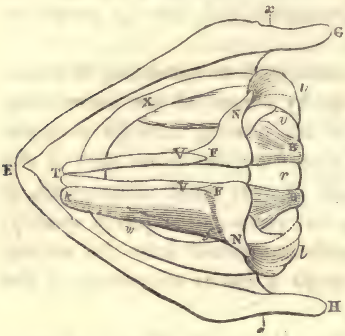
The larynx is the organ of voice. It consists of several cartilages united together by ligaments and articulations, and supplied with a variety of muscles, by which they may be moved together or separately, according to the modifications of the voice.



E *m* C H, the thyroid cartilage;
H, its upper horn;
C, its lower horn, articulated to the cricoid;
A *n* B C, the cricoid cartilage;
A K, the crico-thyroideus muscle.

Above the pile of cartilaginous rings which compose the wind-pipe is placed the cricoid cartilage; the thyroid cartilage embraces the cricoid, and is articulated to its sides so that its lower horn turns round on a point as a fulcrum. Two small cartilages called the arytenoids are articulated to the upper external edge of the cricoid, and the vocal ligaments are stretched from the thyroid to the arytenoids. The aperture between the edges

Bird's-eye view of the larynx from above.



G E H, thyroid cartilage, embracing the ring of the cricoid $r\ u$ X w, and capable of turning on the axis $x\ z$, which passes through the lower horns C, seen in the preceeding figure;
N F, N F, the arytenoid cartilages;
T V, T V, the vocal ligaments.
From N to X run the right lateral crico-arytenoid muscle, the left having been removed.

of the vocal ligaments is called the glottis; and in all the theories which have been advanced it has been admitted that the vocal sound is produced by the breath passing through this aperture, though different explanations have been offered of the way in which the voice is produced. Ferrein compared the vocal ligaments to violin strings, and the current of air which puts them in motion to a violin bow; the different sounds he attributed to various tensions of the ligaments. Dodart found an analogy between the glottis and the embouchure of a flute; the pitch of the sound he supposed to depend on the size of the aperture. Biot thought the way in which the sound of the voice was produced more analogous to a reed, and particularly to that kind of reed which has but lately been introduced into a variety of musical instruments. Savart has lately endeavoured to prove that the sounds of the voice are produced in the same manner as in a lark-whistle, and that the pitch depends on altering the tension of the elastic sides of the small conical tube formed by the part of the larynx immediately before this aperture.

There can be no doubt as to the way in which the sonorous vibrations are produced in the larynx. If a piece of silk riband,

or a strip of paper, parchment, or any other flexible substance, be stretched between the fingers or otherwise, and a current of air either from the mouth or a bellows be directed against one of its edges, a clear musical sound will be produced, varying in pitch according to the tension given it; and, if a riband of thin Indian rubber be employed, the sound will very much resemble that of the voice, and be capable of an extensive range by varying the tension. The itinerant exhibiters of Punch employ a silk riband stretched between two arched pieces of tin, and, placing this between the tongue and the palate, they without sounding the voice pronounce all the articulations of speech by whispering, and imitate the various inflexions of the voice by pressing more or less on the thin sides, thus increasing or diminishing the tension of the riband. Dr. Darwin was the first who appears to have recognised the resemblance of this instrument to the ligaments of the glottis.

The vibrations of an elastic ligament set in motion by the air being thus sufficient to account for the production of the voice, we have only to examine the particular disposition of these ligaments in the larynx, and the precise way in which the air acts upon them. Each vocal ligament, stretched between the arytenoid and the thyroid, presents a sharp edge turned upwards and inwards. Mr. Willis of Cambridge[a] has shown that, if a current of air be made to pass between two stretched surfaces, they will vibrate only when their free edges are parallel;—if they be turned either outwards or inwards, the air will pass without producing any sound. He hence infers that a certain position of the edges of the ligaments is necessary for the air issuing from the lungs to cause them to sound, and this vocalising position is determined by the twisting motion of the arytenoid cartilages.

"That every degree of motion in the glottis is directed by the numerous muscles of the larynx is proved by the beautiful experiment of tying or dividing the recurrent nerves, or the pneumonogastric[b], and thus weakening or destroying the voice of animals."

[a] Of the Mechanism of the Larynx. *Camb. Phil. Trans.* 1832.

[b] "Respecting this celebrated experiment, anciently made by Galen, consult among others W. Courten, *Philos. Trans.* No. 335.

Morgagni, *Ep. Anatom.* xii. No. 20. P. P. Molinelli, *Comment. Institut. Bonon.* t. iii.

J. Haighton, *Memoirs of the Medical Society of London*, t. iii."

But for the operation of the nerves I refer to my former observations on the pneumono-gastric nerve at page 433.

"Man and singing-birds have the power of *whistling*. In the latter, it is accomplished by a larynx placed at each extremity of the windpipe and divided into two portions. The former, though possessing a single and undivided larynx, has probably learned to imitate birds by the coarctation of his lips[c]," which, however, serves only as an embouchure to the column of air contained within the mouth and larynx. The varieties of intonation entirely depend on the alterations of the tongue and on the corresponding motions of the larynx. For the higher sounds the tongue is brought forwards and the larynx raised, and for the lower sounds the tongue recedes and the larynx is depressed.

"*Singing*, which is compounded of speech and a musical modulation of the voice, I conceive to be peculiar to man and the chief prerogative of his vocal organs. The power of whistling is innate in birds; many of them may easily be taught to pronounce words, and instances have been known of this even in dogs. But it is recorded that genuine singing has once or twice only, and then indeed but indifferently and with the utmost difficulty, been taught to parrots; while, on the other hand, scarcely a barbarous nation exists in which singing is not common.[d]

"*Speech* is a peculiar modification of the voice, adjusted to the formation of the sounds of letters by the expiration of air through the mouth or nostrils, and in a great measure by the assistance of the tongue, applied and struck against the neighbouring parts, the palate and front teeth in particular, and by the diversified action of the lips.[e]

[c] "The larynx, even among the most savage people, is capable of imitating the sounds of brutes. Consult, v. c. Nic. Witsen, *Noord en Oost — Tartarye*, ed. 2. Amst. 1705. vol. i. p. 165., respecting the inhabitants of New Guinea of the southern hemisphere, called *Papus*. And J. Adair, *History of the American Indians*, p. 309., respecting the Choktah tribe of North America."

[d] "I have in my hands the testimony of most respectable travellers, in regard, for instance, to the inhabitants of Ethiopia, Greenland, Canada, California, Kamtschatka, &c., and therefore wonder at the assertion of Rousseau, — that singing is not natural to man. *Dictionn. de Musique*, t. i. p. 170. Geneva, 1781. 12mo."

[e] "See Rich. Payne Knight, *Analytical Essay on the Greek Alphabet*. Lond. 1791. 4to. p. 3."

"The difference between voice and speech is evident. The former is produced in the larynx; the latter by the peculiar mechanism of the other organs above described.

"Voice is common to both brutes and man, even immediately after birth, nor is it absent in those unfortunate infants who are born deaf. But speech follows only the culture and employment of reason, and is consequently, like it, the privilege of man in distinction to the rest of animal nature. For brutes, natural instinct is sufficient [f]: but man, destitute of this and other means of

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I am indebted to the powerful Dr. Conyers Middleton for the knowledge of two cases of distinct articulation with at least but little tongue. (*An Enquiry into the Miraculous Powers, &c.* Miscellaneous Works, vol. i. p. 148. 4to.) In his exposure of the *pious* deceptions of weak and wicked Christians during the first centuries of the Christian era, he notices a pretty tale of an Arian prince cutting out the tongues of some of the orthodox party and these being as able to talk as before; nay one (*O hominum impudentia!*), who had been dumb from his birth, gained the faculty of speech by losing his tongue. Granting the fact, and even that the tongues were completely extirpated, he refers, for the purpose of proving there was no miracle in the case, to two relations of similar instances by medical men. (Jussieu, *On Speech without a Tongue. Mém. de l'Acad. des Sciences.* 1718. p. 6.) Professor John Thomson found the speech little impaired after bullets had carried away more or less of the tongue. (*Report of Observations made in the British Hospitals in Belgium, after the Battle of Waterloo; with some Remarks on Amputation.*) Louis, Richter, Huxham, Bartholin, and Tulpius mention similar cases. An instance of good articulation after the loss of the apex and body of the tongue quite down to the os hyoides occurred in this country, and was seen by the Royal Society. (*Account of a Woman who spoke fluently without a Vestige of Tongue. Phil. Trans.* 1742. p. 143. Dr. Parson's *Account of Margaret Cutting, who had lost her Tongue. Phil. Trans.* 1747. p. 621.

[f] Mr. Herbert, in a note to White's *Natural History of Selborne*, p. 227. says he saw Col. O'Kelly's green parrot, about 1799, which sang, perfectly, about fifty different tunes, solemn psalms, and humorous or low ballads, articulating every word as distinctly as a man, without a single mistake, beating time with its foot, turning round upon the perch, and marking the time as it turned; if a person sang part of a song, it would take it up where he left off; and, when moulting and unwilling to sing, turned its back and said, "Poll's sick." The dog to which Blumenbach alludes was seen and heard by Leibnitz (*Op.* vol. ii. p. 180. ii.), who declares it pronounced all the letters of the alphabet except m, n, x, and thirty German words; was three years old when it went to school, and required some years for finishing its education. Locke, however, goes farther than Leibnitz, for he relates a story in his *Essay on Human*

supporting his existence independently, enjoys the prerogative of reason and language; and following, by their means, his social destination, is enabled to form, as it were, and manifest his ideas, and to communicate his wants to others, by the organs of speech."

The elements of which all the spoken languages of mankind are composed consist of the modifications given sometimes to the breath, and at other times to the voice, during their passage through the cavity of the mouth; these modifications are principally effected by the altered positions of the lips and tongue with respect to the fixed parts of the containing cavity.

The classification of these articulations into vowels and consonants has been generally recognised.

The *vowels* are formed by the voice, modified, but not interrupted, by the varied positions of the tongue and lips. Their differences depend on the various proportions between the aperture of the lips and the internal cavity of the mouth, alterable by the different elevations of the tongue. The vowel *aw* (as pronounced long in *a*ll, and short in g*o*t) is formed by augmenting the internal cavity by the greatest possible depression of the dorsum of the tongue, and, at the same time, enlarging the separation of the lips. Departing from this sound there are two series. In one the external aperture remains open, and the internal cavity gradually diminishes by the successive alterations of the tongue; in the other the positions of the tongue are successively the same as in the first series, but the aperture of the lips is diminished. The approximation of the lips produces a more sensible effect as the inner cavity is more enlarged; hence two modifications of the first sounds of the second series are easily recognised, whilst only one variety of the others is readily appreciable, as will be shown in the following table.[g] Each of these vowels may be long or short, according to the duration of its sound in a syllable.

Understanding, (book ii. p. 27.) on the authority of Prince Maurice, and believes it too, of an old parrot that held a rational conversation.

[g] For the more open sounds, the jaws are generally more separated; but this is not indispensable.

TABLE OF VOWELS.

First Series. — The lips fully open.			Second Series. — The lips partially open.			Third Series. — The lips nearly closed.		
	As pronounced			As pronounced			As pronounced	
	Long, in	Short, in		Long, in	Short		Long, in	Short, in
1. *aw*	c*au*ght, f*a*ll	f*o*lly	6. *o*	c*oa*t	Not used.	11. *oo*	c*oo*l	f*u*ll
2. *ah*	f*a*ther, c*ar*	d*u*ll	7. *o*	c*ou*rt				
3. *ae*	n*ae* (Scotch)	m*a*n	8. *eu*	bonh*eu*r (Fr.)				
4. *a*	f*ai*r[h]	m*e*t	9. *eu*	affr*eu*x (Fr.)				
5. *e*	f*ee*t, th*e*	f*i*t	10.	Expressed in German by *ü*, in Danish and Swedish by *i*, in Dutch and French by *u*.				

The above table exhibits all the most usually pronounced vowel sounds, but practised ears might distinguish others intermediate in each series. When these vowels are sounded, the soft palate is raised so as to prevent the voice from issuing through the nasal channels; when, on the contrary, the soft palate is depressed, the partial escape of the breath through the nostrils modifies all the preceding sounds in a very evident manner. To distinguish these two modes of articulating the vowel sounds, we may adopt Dr. Darwin's terms, orisonant and narisonant vowels.

Consonants may be divided into continuous (sometimes called liquids or semi-vowels) and explosive. For the latter, the breath or voice is stopped in its passage through the mouth; for the former, it is allowed a free passage, though the apertures are more narrowed than for the vowels.

But the most comprehensive and important division of these articulations is into aspirates and sonants; the modifications of the breath being meant by the former term, and those of the voice by the latter. In ordinary speaking these are mingled together to form the elementary syllables of language. The aspirates, or sounds indicated by the characters *p*, *f*, *sh*, *s*, *th* (in *th*ing), *t*, *k*, *ll* (Welsh), differ from the sonants, or those represented by

[h] This vowel is much used by the Irish in pronouncing such syllables as *bate fait*, &c., for our English words beat, faith, &c.

b, *v*, *z* (in azure,) *z* (in puzzle), *th*, (in *th*e), *d*, *g* (in gay), *l*, only by the latter being accompanied with the vocal sound.

Every sonant has its corresponding aspirate, though many of the latter are unknown to the English language; such are the aspirates corresponding to the sonants *r*, *m*, *n*, *ng* (in so*ng*), &c.

When forming the component parts of syllables, the aspirates, as well as the sonants, are always articulated with sonant vowels. An aspirate vowel, followed by its vocal enunciation, is always represented by the character *h*, but it is never pronounced separately, except in whispering.

The consonants, like the vowels, are divided into orisonant and narisonant. The only narisonant consonants in our language, are those corresponding to the orisonant explosives *b*, *d*, and *g* (in gay), — viz. *m*, *n*, and *ng* (in so*ng*). By this mode of pronunciation the sounds are rendered continuous.

TABLE OF CONSONANTS.

Continuous.			Explosive.			
	Aspirates.	Sonants.		Aspirates.	Orisonants.	Narisonants.
1.	*f*	*v*	10.	*p*	*b*	*m*
2.	—	*y*	11.	*t*	*d*	*n*
3.	*sh*	*z* & *j* in azure.	12.	*k*	*g* in gold.	*ng* in so*ng*.
4.	*s*	*z* in zany.				
5.	*th* in *th*ink	*th* in *th*e				
6.	(not used)	*r*				
7.	*ll*	*l*				
8.	—	*l* in fi*ll*e (Fr.)				
9.	*ch* in lo*ch* (Scotch) na*ch* (Ger.)	*g* in sagen (German) gemis (Sp.)				

This table shows that, for all the consonants employed in the English language, only ten positions of the mouth are required, the modifications being effected by other means. Among the modifications not already described, may be particularised the reduplication of the 10th, 11th, and 12th sounds; the first occasioned by the vibratory motion of the lips, the others by that of the tongue.

Observations. Sound, 1.—The lower lip presses on the upper teeth, but allows the air to escape between them; a similar sound is produced by allowing the breath to pass through the lips when nearly closed. 2, 3, 4, 5.—These sounds may be considered as the continuation of the first series of vowel sounds; for, by placing the mouth in the position for *e* (5.), and continuing to elevate the back part of the tongue, and, at the same time, to curl its tip, these sounds will be successively produced. 6, 7, 8.—These sounds differ from the preceding four, inasmuch as that the *back part* of the tongue does not approximate to the palate; the mouth being placed for the second vowel, the front of the tongue is elevated so as to touch the palate just above the teeth; for the *r*, the point is drawn back, so as to allow the air to escape; and for the *l*, the point is firmly pressed against the palate, and the breath escapes by the two sides; for the *l* (in fi*ll*e), the air escapes with more difficulty. 9.—These are used in the Gaelic and German, but not in English. 10, 11, 12.—These sounds are produced by the forcible escape of the breath, or voice, after a complete obstruction by the lips or tongue. The obstruction by the lips gives *p*, or *b*; that by the front of the tongue above the upper teeth, *t*, or *d*; and that by the back of the tongue against the palate, *k*, or *g*; these different articulations may therefore be distinguished as Labial, Dental, and Palatal. When the sound escapes through the nostrils it becomes continuous; the *m*, *n*, and *ng* are therefore not explosives.

The alphabetic characters, invented as visual and permanent representations of the articulations of speech, are very inadequate to effect the purpose intended. In the English language there are but five characters to indicate all the varieties of the vowels, viz. *a*, *e*, *i*, *o*, *u*. Of these, one only is pronounced, when uncombined, as a pure vowel; this is *e*, — the 5th sound in the table of vowels: the other four are diphthongs or combinations of two vowels; *a* is the 4th and 5th; *i* is the 3d and 5th; *o* is the 6th and 11th; and *u* is the 5th and 11th. When constituting parts of syllables, the same character represents many different vowel sounds.

The consonantal characters are not quite so arbitrary, though among these there are some simple sounds expressed by two letters, and others which have no character to denote them; and on the other hand there are several redundant letters representing

two simple sounds: *f, v, r, l, p, t, k, b, d, m,* and *n,* are generally constant in their signification. The simple sounds represented by two characters are *sh, th* (in *th*ink), *th* (in *th*e), and *ng* (in so*ng*). The single characters representing more than one sound are *s* (in *s*ea, hi*s*, *s*ure, and vi*s*ion); *z* (in *z*any and a*z*ure); *g* (in *g*ay and *G*eor*g*e). The redundant letters are, *c* (having the sound either of *s* or *k*); *q* (*k* followed by the eleventh vowel); *j* (compounded of *d* and the second pronunciation of the *z*,—the same as the *g* in *G*eorge); and *x* (standing for *ks*, or *z*). Y, as generally pronounced, and *w*, are not consonants; the first represents the 5th, and the second the 11th vowel of the table, when immediately succeeded by another vowel.

The consonants will be best compared by articulating them all, uniformly preceded or followed by the same vowel; as *fe, she, se, the, pe, te, ke,* &c. or *ef, esh, es, eth, ep, et, ek,* &c.

It is by no means improbable that the progress of modern art may present us at some future time with mechanical substitutes for orators and preachers. For, putting aside the magic heads of Albert the Great and Roger Bacon, Kratzenstein actually constructed an instrument to produce the vowels [i], and De Kempelin has published a full account of his celebrated speaking machine which perfectly imitated the human voice.[k] The celebrated French mechanician, the Abbé Mical, also made two heads of brass which pronounced very distinctly entire phrases; these heads were colossal, and their voices were powerful and sonorous. The French government refusing, it is said, in 1782, to purchase these automata, the unfortunate and too sensitive inventor, in a paroxysm of despair, destroyed these masterpieces of scientific ingenuity. More recently, Mr. Willis of Cambridge has published a very interesting essay on the vowel sounds, in which he describes an instrument for producing them, and at the same time explaining their physical causes. My excellent and highly distinguished friend Professor Wheatstone, to whom the analysis of the elementary sounds I have above given is due, and whose valuable assistance in this section, as well as those on vision and hearing, I am proud to acknowledge, has also made many experiments illustrating the mechanism of speech, and succeeded in reconstructing and improving De Kempelin's machine.

[i] *Observations sur la Physique,* par Rosier, Supplement, 1782. p. 758.

[k] *Ueber den Mechanismus der Menschlichen Sprache.* Vienna, 1791.

As I have now fully explained the various articulations used in oral language, it only remains for me to investigate the difference between the inflexions of the voice in singing and in speaking.

The various muscular adaptations of the larynx render it capable of producing every inflexion of musical tone within a certain compass, seldom exceeding that of two octaves. In *singing*, sounds, each constant in its degree of tune, follow each other according to the rules of melody; while in *speaking*, the voice slides up and down, and "does not dwell distinctly, for any perceptible space of time, on any certain level or uniform tone, except the last tone on which the speaker ends or makes a pause." Provincial dialects, and even individual modes of speaking, differ much in the extent and nature of these slides. Steele has endeavoured to establish a system of notation for these inflexions, and other modifications of the voice necessary to be observed by the orator, and has by this means proposed to perpetuate the most splendid specimens of histrionic, forensic, and senatorial eloquence.[1] To proceed farther with this subject would be an infringement on the province of philology.

"We must just mention certain other modifications of the human voice, of which some, as hiccup and cough, belong more properly to pathology than to physiology, but are very common in the most healthy persons; and others, as crying and laughing, appear peculiar to the human race.

"Many of these are so closely allied as frequently to be converted into each other; most also are variously modified.

"In *laughter* there is a succession of short, and, as it were, abrupt expirations."[m] In it, there is more or less noise at each little expiration, from a mere sort of rustling sound to loud peals; the mouth is more or less lengthened, and its angles drawn up, and in extreme laughter it is opened still more by the descent of the lower jaw; if hearty, the tears run over, the head, and even the body, shakes, respiration is interrupted, and

[1] *Prosodia Rationalis; or, An Essay towards establishing the Melody and Measure of Speech, to be expressed and perpetuated by peculiar Symbols.* 2d. edit. London, 1779.

[m] "Fr. Lupichius, *De Risu.* Basil. 1738. 4to.

Traité des Causes Physiques et Morales du Rire. Amst. 1783. 8vo."

actual pain of the sides and diaphragm is felt.[n] Some of our comedians have absolutely agonised me. It arises from drollery, the anticipation of gratification, or actual gratification, or tickling; it is also common in hysteria and insanity. Smiling is the first degree of the same changes of the mouth.

"*Coughing* is a quick, violent, and sonorous expiration, following a deep inspiration."[o] In coughing, the mouth opens that the air may rush in that direction, since the current is not required in the nostrils as in sneezing, and these would not afford sufficient vent. The glottis lessens just before the expiration, and the transverse muscular fibres of the trachea lessen its diameter and thus increase the force with which the expelled air rushes.[p] Coughing is induced by the very slightest irritation of the larynx. But irritation of any part of the respiratory apparatus may occasion it, as well as irritation of a distant part influencing the respiratory apparatus sympathetically. It sometimes arises from a morbid sensibility of the nerves, so that I have known it occur for months at the full distension of *every* inspiration, except during sleep; and in other instances on the slightest touch of the outside of half the chest. There are many varieties of the sound and respiratory actions of cough.

"*Snoring* is" said by Blumenbach to be "a deep, sonorous, and, as it were, tremulous inspiration, from the vibration of the velum palati during deep sleep." We can, however, snore voluntarily while awake; and, by allowing a portion of the tongue to rise into contact with the velum, I can snore so that the sound shall proceed from vibrations of the nose as well as of the velum, evident both to the ear and to the fingers placed upon the nose. I can also increase the proportion of the nasal vibrations at pleasure, by allowing more of the tongue to rise into contact with the velum and palate, and cause them only to take place, even if the mouth is closed: and, if it is closed, snoring is always more or less nasal. In sleep, snoring may be palatal or nasal, or both in various proportions. The sound, as well as its situation, varies accordingly as it is palatal or nasal, or more one than the other.

[n] "Sport that wrinkled Care derides,
And Laughter holding both his sides."

L'Allegro.

[o] "J. Melch. Fr. Albrecht, (Præs. Hallero) *Experimenta in vivis animalibus circa tussis organa exploranda instituta.* Gotting. 1751, 4to."

[p] Sir C. Bell, *Phil. Trans.* 1832. p. 300. sqq.

"*Sneezing*, generally the consequence of an irritation of the mucous membrane of the nostrils," though the glare of the sun upon the eyes will produce it, "is a violent and almost convulsive expiration, preceded by a short and violent inspiration."[q] In sneezing, the opening of the fauces is lessened, and the head bent back, that the current may be directly through the nostrils, in which the irritation generally exists.

"*Hiccup*, on the contrary, is a sonorous, very short, and almost convulsive, inspiration, excited by an unusual irritation of" the stomach, and Blumenbach says only of "the cardia."[r] In hiccup, I think that, after the inspiration has proceeded a certain length, the glottis closes, and the diaphragm endeavours in vain to contract farther.

"In *crying* there are deep inspirations, quickly alternating with long and occasionally interrupted expirations.[s]

"*Sighing* is a long and deep inspiration, and the subsequent expiration is sometimes accompanied by *groaning*.[t]

"Nearest in relation to sighing is *gaping*[u], which is produced by a full, slow, and long, inspiration, followed by a similar expiration, the jaws at the same time being drawn asunder, so that the air rushes into the open fauces and the Eustachian tubes." We gape chiefly during fatigue or hunger; when we are but half awake, either before or after sleep; and in ague and hysteria. "It occurs from the blood passing through the lungs too slowly; *v. c.* when the pressure of the air on the body is diminished, as upon very high mountains." A peculiar feature of gaping is the propensity it excites in others to gape likewise. This is universally remarked. But the fact is included in the more general fact of gaping being excited by merely thinking of it, whatever be the means of association by which it enters into our thoughts, whether by seeing it represented in a picture, by reading of it, or having it mentioned to us. If this is the case, the view of others gaping may well be supposed sufficient to excite it.

q "Marc. Beat. L. J. Porta, *De Sternutatione*. Basil. 1755. 4to."

r "C. J. Sig. Thiel, *De Singultu*. Gotting. 1761. 4to."

s "J. F. Schreiber, *De Fletu*. L. B. 1728. 4to."

t "Dav. C. Em. Berdot, *De Suspirio*. Basil. 1756. 4to."

u "Just. Godofr. Günz, (Præside Walthero) *De Oscitatione*. Lips. 1738. 4to."

Dr. Brachet contends that the muscular power of the extreme bronchial twigs and air cells operates both in these violent and in the ordinary degrees of respiration. He divided the spinal chord in the neck of cats so that respiration ceased and was continued artificially. He then applied hellebore to their nostrils, and little expiratory shocks took place, very evident and necessarily independent of the respiratory muscles.[x]

Haller is well worth reading on these subjects.[y]

Most authors assert that the opening of the glottis enlarges at inspiration and lessens at expiration; but Dr. H. Ley makes it probable that, in simple and undisturbed breathing, the glottis remains open.[z] In strong muscular efforts the glottis closes, that the chest may be immovable. Swimming and leaping are shown by M. Bourdon to be impossible unless it is closed; for he prevented them by inserting a tube into a wound made by him in the trachea of poor brutes.

Although, with the exception of mocking birds, brutes make no articulate sounds, they have a language perfectly intelligible to one another. They make one noise to express joy, another terror, another to summon their young, &c., and comprehend the meaning of sounds made by us, not only of an inarticulate kind, but also articulated. The sagacity of some dogs in this respect is astonishing. "They learn to understand not merely separate words or articulate sounds, but whole sentences expressing many ideas. I have often spoken," continues Gall, "intentionally of objects which might interest my dog, taking care not to mention his name, or make any intonation or gesture which might awaken his attention. He, however, showed no less pleasure or sorrow, as it might be; and, indeed, manifested by his behaviour that he had perfectly understood the conversation which concerned him. I had taken a bitch from Vienna to Paris; in a very short time she comprehended French as well as German, of which I satisfied myself by repeating before her whole sentences in both languages."[a] An accurate observer of nature, and one familiar with brutes, Hogg, the late Ettrick shepherd poet, to substantiate the same opinion, relates the following anecdote. He was going to visit

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[x] l. c. p. 298. sq.

[y] *El. Physiol.* lib. viii. sect. iv. p. xxx—xl.

[z] *London Medical Gazette,* June 27, 1834.

[a] *Sur les Fonctions du Cerveau,* t. v. p. 49. sq.

a friend for a fortnight, but was desirous that a particular dog should not accompany him, as it was always "breeding some uproar." While the animal was near him he mentioned his intention to his mother in the evening. The dog was to be locked up till some time after he had started. But in the morning, when the time came, it was not to be found. "The d—'s in that beast," said he, "I will wager that he heard what we were saying yesternight, and has gone off for Bowerhope as soon as the door was opened this morning." A great flood had taken place in the night, so that the Yarrow was impassable, and Hogg had to go by St Mary's Loch, and cross in a boat. But though it appeared impassable by any living creature, the dog had swam it early in the morning, and was found by Hogg, "sitting, 'like a drookit hen,' on a knowl at the east end of his friend's house, awaiting his arrival with great impatience." [b]

As the exertion of every power is a gratification, brutes take an intense pleasure in making the noises of which they are capable. The singing of some birds, and the chattering and squalling of others, are examples of this.

The voice of some small brutes is, like the muscular powers of others, far greater than in large animals proportionally, and of some even absolutely. A grasshopper, weighing an eighth of an ounce, may be heard at the distance of the sixteenth of a mile; and Americans have calculated that a man, weighing as much as 1600 grasshoppers, were his voice in proportion, would be audible at the distance of 1000 miles, and when he sneezed would cause the house to be in danger of falling, as the walls of Jericho tumbled at the sound of the trumpet.

[b] Blackwood's *Edinburgh Magazine*. Feb. 1824.

CHAP. XXII.

THE EXTERNAL SENSES IN GENERAL, AND TOUCH IN PARTICULAR.

" The other office of the nerves we found to consist in communicating to the sensorium" (or organ of the mind) "the impressions made by external objects. This is accomplished by the external senses, which are, as it were, the watchmen of the body and informers of the mind."

The external senses are usually considered to be five :—Touch, taste, smell, sight, and hearing. But our feelings referrible to sensation or consciousness are very numerous. Besides our strictly mental feelings, we have a great variety of feelings in the body at large. To say nothing of hunger and thirst, we may feel weak or strong. The sensation of weakness is very distressing, and often complained of in the epigastric region. The removal of this makes us cognisant of a feeling of which otherwise we think but little,—a feeling of general support and mutual elastic resistance, as it were, between all the particles of the frame: and exhaustion makes us conscious of what was the comfort of this feeling. We feel the state of our muscles, whether they are relaxed or contracted, or at least the position of the parts which they move. We feel the state of tone or exhaustion of muscles. We feel heat and cold in their various degrees, pains, and endless uneasy sensations of distension, weight, pricking, smarting, &c. &c., a large number of which are usually referred to the sense of touch. But the sensation induced mechanically by the contact of something with us is properly called touch. Forms of sensation may be peculiar to certain parts.

" The five external senses alone belong to our present subject. For to regard, with Gorter, the stimulus which inclines us to relieve the intestines," &c., as so many distinct senses, is unnecessary minuteness, as Haller long since observed.[a]

[a] " J. De Gorter, *Exercitationes Medicæ*, iv. Amst. 1737. 4to."

By means of the external senses only do we learn the existence of the world around us. "With every sense an animal discovers a new world; thus creation is to it increased or diminished accordingly as its senses are more or less numerous." "Provided with senses, it enters into communication with the university of nature, and associates with surrounding beings; a continual action and reaction are established between animate and inanimate nature."[b] They are the seat of almost constant gratification. Without them, indeed, we should not only be ignorant of the surrounding world, but our mental faculties would never come into operation. We could not judge of objects of sight, hearing, or touch, by our lower intellectual faculties; nor would our higher intellectual faculties come into play, nor our various inclinations be called forth. Some writers, hardly deserving the name of philosophers, have been misled by these truths, and declared that the external senses give rise to our intellectual and moral powers. Were this the case, persons of acute external sense, and those numerous savages and brutes which surpass us in one external sense or other, would be the most eminent in intellect. Gall found it necessary to refute these errors at length.[c] Not even can an organ of external sense give rise to a sensation, except in the brain, or what is tantamount to brain in every brute.

Gall observes that,

"1. Every nerve of sense has its particular origin: no one arises from the brain, or from another nerve; but the filaments of each proceed from particular masses of pulpy substance.

"2. Each nerve of sense differs from the others in size, structure, colour, and consistence.

"3. The apparatus of some nerves are more or less complicated, more or less numerous in the different kinds of animals.

"4. There is no proportion, either direct or constantly uniform, between the size of the brain and of the nerves.

"5. There is no fixed proportion between the nerves of sense in the different kinds of animals, nor in individuals of the same species.

"6. The female has not nerves of sense larger or smaller than the male.

[b] Gall, l. c. 4to. vol. i. p. 149.

[c] Ibid. ll. cc. 4to. vol. i. p. 223. sqq.; also p. 149. sqq. 8vo. t. i. p. 114. sqq.

" 7. In different species of animals, and in individuals of the same species, the nerves of sense are developed and decline at very different periods.

" 8. No decussation of any other nerve than the optic is at present known, and its decussation is not found in all species of animals.

" 9. The corresponding nerves of each side communicate together by commissures, and in other parts of the brain by branches."

Again, that,

" 1. To the functions of the senses, material instruments are indispensable.

" 2. That the nerves merely communicate the impression of the external world to the brain that it may be modified by this.

" 3. Every nerve of sense can receive but certain impressions, and the functions of one sense cannot be performed by another.

" 4. The delicacy of every sense is ordinarily proportionate to the perfection and development of the apparatus, and probably also to the number of apparatus.

" 5. The particular functions of the senses have not the same force in different species of animals, nor in different animals of the same species: the animal which has acute sight may have dull hearing.

" 6. The nervous system of the senses may, like other systems, acquire a higher activity by unusual irritants, from inflammation, &c.

" 7. The derangement of the functions of the senses that follow lesion of the brain do not affect the opposite side any more than those of the spinal chord, at least according to my present experience.

" 8. The functions of the different senses manifest themselves at different periods, according to the development of these organs. It is asked how, and for what purpose, some animals are born with senses perfectly developed, at least with the eyes and ears open, and others with them closed. This peculiarity is not always in relation to the power of using the extremities more or less promptly; for the new-born child is as incapable of locomotion as the new-born puppy.

" 9. All the functions of the senses gradually decline in old age." According to some physiologists this is the result only of the

organs of the senses becoming habituated to external impressions, so that these are continually less and less strong. But in old age the functions of the senses grow weak, because the organs of the senses diminish. The nervous filaments, and their nutrient substance, waste, as well as the pulpy substance in general, and all the nerves begin to atrophy. Hence Pinel did not find, in the labyrinth of deaf old men, the soft substance which exists in men who hear. Hence the nerves of old persons are much smaller than of those in the vigour of life. As this diminution does not occur at the same time in all the nervous system, it follows that all the functions do not decline equally at the same time, as would be the case if they declined more and more only by habituation to impressions. Some even explain by habit the fact of our having in health no sensation of what is passing within us in our organic or automatic life. I should ascribe this rather to an original design of nature, which probably accomplishes it by the tenuity of the filaments that communicate between the nervous system of the chest and abdomen and the nervous system of the vertebral column, the senses, and the brain.

" 10. The doubleness of any sense does not prevent our sensation of objects from being simple: in the same manner our consciousness is single, notwithstanding the five different functions of the senses."

A sensation lasts a certain time after the exciting cause has ceased. Thus, if a piece of wood, with one end ignited, is whirled round, we see a luminous ring; the sensation produced by the wood in each point of the circle continuing till the wood arrives at that point again: a rocket forms a train. A sensation is sometimes renewed, as when, after having looked at the sun, we close our eyes and its figure returns. According to the law of all vital excitement, sensations are more acute the less they have been excited, and *vice versa*. Thus, after having been in a strong light, we at first see nothing on entering a darkened apartment, but gradually distinguish objects in it, and, on returning into the light, find the glare very disagreeable: the same tepid water feels warm to one hand previously immersed in cold water, and cold to the other previously placed in warm water.

" *Touch* merits our first attention, because it is the first to manifest itself after birth, its organ is most extensively spread

over the whole surface, and it is affected by many properties of external objects."

"It is less fallacious than the rest of the senses, and by culture capable of such perfection as in some measure to supply the deficiency of others, particularly of vision.[d]

The direct pleasure of the sense of touch is far more exquisite than of any other sense, and is therefore employed by nature for the raptures of sexual intercourse.

"The skin, whose structure we formerly examined, is the general organ of touch.[e] The immediate seat of the sense is the papillæ of the corium, of various forms in different parts, commonly resembling warts[f], in some places fungous[g], in others filamentous.[h] The extremities of all the cutaneous nerves terminate in these under the form of pulpy penicilli."

The nerves of general sensibility, and as far as we know of touch in particular, are the ganglionic portion of the trigeminum and the ganglionic or posterior spinal nerves and all their ramifications.

"The *hands* are the principal organs of touch, properly so called, and regarded as the sense which examines solidity; and their skin has many peculiarities. In the palms and on each side of the joints of the fingers, it is furrowed and free from hairs, to facilitate the closing of the hand: and the extremities

[d] "Consult Rol. Martin, *Schwed. Abhandl.* vol. xxxix. 1777.
G. Bew, *Memoirs of the Society of Manchester,* vol. i. p. 159.
Ch. Hutton, *Mathematical Dictionary,* vol. i. p. 214."

"Lecat speaks of a sculptor, Ganibasius de Volterre, who, being blind, felt faces, and then modelled them in clay. The man of Puiseaux, born blind, estimated the distance of the fire by the degree of heat, and of bodies by the action of air upon his face. Saunderson, by exploring a series of medals with his hands, distinguished the genuine from the spurious, although the latter were so well counterfeited as to deceive a connoisseur with good eyes; and he judged of the accuracy of mathematical instruments by passing the ends of his fingers upon their divisions. Like the blind man of Puiseaux, he was affected by the least vicissitude of the atmosphere, and could perceive, especially in calm weather, the presence of objects not more than some paces distant." Gall, l. 4to. vol. i. p. 222.

[e] "F. De Riet, *De Organo Tactus,* L.B. 1743. 4to. reprinted in Haller's Anatomical Collection, t. iv."

[f] "Dav. Corn. de Courcelles, *Icones Musculor. Capitis.* Tab. i. fig. 2, 3."

[g] "B. S. Albinus, *Annotat. Academ.* l. iii. tab. iv. fig. 1, 2."

[h] "Ruysch, *Thesaur. Anat.* iii. tab. iv. fig. 1. *Thes.* vii. tab. ii. fig. 5.
B. S. Albinus, l. c. L. vi. tab. ii. fig. 3, 4."

of both fingers and toes are ridged internally by very beautiful lines more or less spiral [i]; and are shielded externally by nails.

"These scutiform *nails* [k] are bestowed upon man and a few other genera of mammalia only (we allude to the quadrumana which excel in the sense of touch) [l], for the purpose of resisting pressure, and thus assisting the action of the fingers, while examining objects.

"They are of a horny nature, but on the whole very similar to the epidermis. For under them lies the reticulum, which in negroes is black [m]; and under this again is found the corium, adhering firmly to the periosteum of the last phalanx. These constituent parts of the nails are striated lengthwise. The posterior edge, which, in the hands, is remarkable for a little lunated appearance, is fixed in a furrow of the skin; and the nails, growing constantly from this, are protruded forwards, so as to be perfectly renewed about every six months."

Dr. Breschet considers that the organ of touch is not a mere nerve, but that an apparatus exists as in the eye and ear: — that, like the optic nerve entering the sclerotic, the nerves of touch lose their neurilema on entering the cutis and derive a new covering from its outer part, and then, terminating in a round extremity or projecting papilla, are covered by a thin layer of epidermis indispensable to the sense of touch.[n]

Weber has shown that the tactile power of the skin is not proportionate to its sensibility. Thus the mammæ are easily tickled,

[i] "Grew, *Phil. Trans.* No. 159."

[k] "B. S. Albinus, *Annotat. Academ.* l. ii. tab. vii. fig. 4, 5, 6."

[l] "Namely, simiæ, papiones, cercopitheci, and lemures, the apices of whose fingers in their four hands are very soft, and marked, as in the human subject, with spiral lines.

"Physiologists have disputed whether the sense of touch is bestowed on any besides man and the *quadrumana*." "On one side, I would grant to both parties that the snowy hands of a delicate girl must enjoy a much more exquisite sense of touch than what I call the fingers of brutes. But, on the other, I have frequently seen simiæ and papiones possessing much softer fingers, and using these fingers to explore surfaces much more dexterously, than many barbarous nations and innumerable persons among the lower orders of Europeans whose hands have been hardened by labour."

[m] "B. S. Albinus, *De Habitu et Colore Æthiopum*, fig. 3."

[n] *Nouvelles Recherches sur la Structure de la Peau*, par M. G. Breschet. Paris, 1835.

and susceptible of great pain when irritated, and yet are very moderately endowed with the sense of touch. The armpits, flanks, soles, and other ticklish parts have a comparatively slight power of distinguishing objects by touch. "Who was ever made to laugh by tickling the ends of his fingers? and yet they are possessed of a tactile accuracy far exceeding that of any other portion of the skin." Mere sensibility exists in all the surfaces and solids, and under disease may give sensations; and in some internal parts, as the upper and lower part of the alimentary canal, we continually have sensation: but, whatever be the irritation of the stomach or bowels or larynx, substances within them are felt very indistinctly.

The different parts of the skin vary exceedingly in their tactile power. Weber remarks that, if the skin of a person whose eyes are shut is touched with the two points of a compass an inch asunder, he at once perceives that he is touched in two places. But, by moving the points nearer and nearer to each other, the skin feels at length as if touched by simply one body, and this body feels as if rather longer in the line of junction of the points of the compass. There is, however, the greatest difference in different parts as to their power of still feeling that there are two bodies when these are approximated. The tips of the fingers and of the tongue distinguish the bodies at the smallest distance; while the middle of the arm and thigh, the centre of the cervical and dorsal spine, cease the soonest to distinguish at large distances. In himself Weber found the tip of the tongue distinguish two bodies, as well in their horizontal as perpendicular direction, till their distance from each other was within half a French line; the inner surface of the tips of the fingers within one, &c.

He lays it down as a law, that, the more gifted with touch are any portions of the skin, the greater will the distance appear of any two bodies from each other though placed at the very same distance. Thus, "if the points of a compass, distant from each other one or two lines, applied to the cheek, just before the ear, be then moved successively to several parts of the cheek, we shall find, on approaching the angle of the mouth, that the points will appear to recede from each other;" or, if the ends of the forefinger and thumb are held together, and their tips passed in a

line from the ear to the upper or under lip, they will feel more and more distant from each other as they approach these.

If the points of the compass, kept at the same distance from each other, are applied to two contiguous surfaces, enjoying voluntary motion, as to the two lips, they will appear more distant than when applied to one surface: in fact in the case of the lips, though, when distant from each other half a line, they appear as two, yet, if applied to one lip only, they appear as one. Nay the points, though at the same distance from each other, will seem more distant when applied to two portions of the skin differing in structure and function, than when applied to portions resembling each other, even though more sensible. Thus, if the points are placed one upon the inner surface, and one upon the red outer part of the lips, they appear more distant from each other than when both are applied, though at the same distance, on the outer red surface which is so much more sensible.

When the points of the compass are placed horizontally on the axis of a limb, they are distinguished as two more clearly than when placed vertically. But the reverse occurs, if they are placed on the trunk.[o]

He finds the left hand more sensible of temperature than the right in most persons, probably from its epidermis being thinner through less use. When the hands, being of the same temperature, were plunged into separate vessels of hot water, as the person lay in bed, the left hand was believed to be in hotter water, though the temperature was two degrees lower than that of the water in the other vessel. A difference of one third of a degree is readily detected by the hand if placed successively in two vessels of water. The judgment is more accurate when the temperature is not much above or below the usual temperature of the body; water at 98° being more readily distinguished from water at 100°, than water at 120° from water at 118°; just as sounds are best discriminated when neither very acute nor base nor loud. A large surface receives stronger impressions than a smaller. If the forefinger of one hand is immersed

[o] I have always been struck with the erroneous judgment I form of the spot of the trunk, or arms, or legs, in which an itching or tingling is felt. So satisfied in general am I that I cannot put my finger on the spot where I feel the tingling, unless I use my eyes, that I have frequently amused myself with observing what a blunder I was sure to make.

in water at 104°, and the whole of the other hand in water at 102°, the cooler water will be thought the warmer: and water, borne by a forefinger, will seem to scald the whole hand. Minute differences are appreciated by plunging the whole hand successively into two vessels of hot water, which are imperceptible to a single finger.

Differences of temperature and weight are best ascertained when the perceptions are not simultaneous, but successive: just as is the case with differences in objects of taste, smell, and hearing. If an acid and a sweet substance are applied to the tongue with pencils in rapid succession, they are nicely distinguished: but not if applied together. It is the same if two vials of odorous fluids are applied to the nostrils; and two notes are always better distinguished if struck in succession than together. Vision is no exception, because, although we compare two lines best when placed side by side, we in fact do not view them simultaneously, but in rapid succession; since nothing is seen accurately unless its image falls on the retina at the extremity of the optic axis.

Persons differ greatly in their power of estimating weight, and practice increases it considerably. Men accustomed to estimate weights by poising them will distinguish a difference of a thirtieth part in two bodies. They use the same hand for each weight in instant succession. The intervention of a few seconds does not prevent accuracy. A true estimate may be made although the second weight is poised twenty seconds after the first; but an interval of forty seconds prevents accuracy. The sense of sight is more accurate, for a well-practised eye will distinguish a difference of a hundredth part in the length of two lines: and the ear surpasses the eye, for a well-practised musical ear will distinguish between two sounds differing only $\frac{1}{320}$,— the number of vibrations being calculated that are made by the sounding bodies in a given time. If two lines differ only $\frac{1}{11}$ in length, the difference may be perceived although the one is looked at fifty or sixty seconds after the other. If they differ $\frac{1}{21}$, an interval of thirty-five seconds may elapse. If they differ $\frac{1}{60}$, an interval of three seconds is the longest compatible with accurate judgment.[p]

Not only does touch appear too general an expression for the

[p] *De Pulsu, Resorptione, Auditu et Tactu. Annotationes Anatomicæ et Physiologicæ*, auctore Henrico Ernesto Weber. Lipsiæ, 1834.; and Dr. Graves's Analysis of it, in the *Dublin Journal of Medical Science*, March 1836.

endless feelings of which we are susceptible, but some feelings, apparently referred with justice to this sense, are considered by many writers as referrible to other modes of sensation. Dr. Spurzheim[q] says, "It may still be asked whether feeling produces ideas of consistency, of hardness, of softness, of solidity and fluidity, of weight and resistance? I think it does not. For the mind to examine these qualities employs the muscular system rather than the sense of feeling properly so called." This opi, nion accords with that of Dr. Brown[r], who states, "The feeling of resistance" (of which he considers the qualities enumerated above as modifications) "is, I conceive, to be ascribed, not to our organ of touch, but to our muscular frame, to which I have already directed your attention, as forming a distinct organ of sense; the affections of which, particularly as existing in combination with other feelings, and modifying our judgments concerning these (as in the case of distant vision, for example), are not less important than those of our other sensitive organs. The sensations of this class are, indeed, in common circumstances, so obscure as to be scarcely heeded or remembered by us; but there is probably no contraction, even of a single muscle, which is not attended with some faint degree of sensation that distinguishes it from the contractions of other muscles, or from other degrees of contraction of the same muscle."

This opinion was originally advanced by the profoundest physician among my predecessors at St. Thomas's Hospital,—Dr. Wells[s], in the following words:—"What is there within us to indicate these positions of the body? To me it appears evident, that, since they are occasioned and preserved by combinations of the actions of various voluntary muscles, some feeling must attend every such combination, which suggests, from experience, perhaps, the particular position produced by it. But in almost all the positions of the body, the chief part of our muscular efforts is directed toward sustaining it against the influence of its own gravity. Each position, therefore, in which this takes place, must be attended with a feeling which serves to indicate its relation to the horizontal plane of the earth."

Sir C. Bell has repeated these opinions, but without any refer-

[q] *Phrenology.*

[r] *Lectures on the Philosophy of the Human Mind.* 2d edit. 1824. p. 480.

[s] *Essays,* 1818. p. 70.

ence to Dr. Wells or the other two physicians, although he shows himself acquainted with Dr. Wells's writings.[t]

"Why are nerves, whose office is to convey sensation, profusely given to muscles, in addition to those motor nerves which are given to excite their motions? To solve this question, we must determine whether muscles have any other purpose to serve than merely to contract under the influence of motor nerves. For if they have reflective influence, and if their condition is to be felt or conceived, it will presently appear that the motor nerves are not suitable internuncii betwixt them and the sensorium. I shall first inquire if it be necessary to the governance of the muscular frame, that there be a consciousness of the state or degree of action of the muscles? That we have a sense of the condition of the muscles appears from this: that we feel the effects of over-exertion or weariness, and are excruciated by spasms, and feel the irksomeness of continued position. We possess a power of weighing in the hand; what is this but estimating the muscular force? We are sensible of the most minute changes of muscular exertion, by which we know the position of the body and limbs, when there is no other means of knowledge open to us. If a rope-dancer measures his steps by the eye, yet, on the other hand, a blind man can balance his body. In standing, walking, and running, every effort of voluntary power which gives motion to the body is directed by a sense of the condition of the muscles, and without this sense we could not regulate their actions, and a very principal inlet to knowledge would be cut off."[u]

Weber illustrates this opinion of Dr. Wells, by supporting the hands of a blindfolded person on cushions, and placing unequal weights upon them. If the difference is great, it will be felt. But, if it is small, it will not be noticed till the hands are raised, — till the muscles feel what resistance they have to act against. Weber found in most men a more accurate sense of the amount of pressure on the left side than on the right. A minute substance in contact with the skin is always judged to be perpendicularly situated in regard to it, as rays of light are always seen in a

[t] The British Association has allowed the compiler of the report on the Physiology of the Nervous System, to refer to Sir C. Bell alone on this point, without any allusion to the previous writings of Dr. Wells, Dr. Brown, or Dr. Spurzheim.

[u] *Phil. Trans.* 1826.

direction perpendicular to the point at which they impinge on the retina. It may be said, that, if a hair is pulled, we do not conceive it to be pulled perpendicularly whatever be the direction. But Weber replies that we judge here of the direction by the direction of the muscular effort necessary to keep the head steady at the time. If muscles are not called into play, but the head is held steady by one person while another presses firmly around the hair, the direction, whatever it be, in which the hair is pulled, cannot be judged of.

We have seen that Dr. Spurzheim thought he had established a cerebral organ for judging of these sensations of weight or resistance.[x]

The varieties of the feelings both of consciousness and sensation in the animal kingdom must be infinite. Brutes probably have sensations from the external world of which we are insusceptible, and those especially which are minute are no doubt sensible to external circumstances, which are far too delicate to produce an impression upon us. Every animal is destined for a certain peculiarity and amount of sensation from certain substances and circumstances, in accordance with the destination of its mode of existence. Brutes will feel the approach of changes in the weather long before we are aware of what is coming; and know even the direction of a coming storm.

All brutes most probably have the sense of touch: and the more delicate and soft the external parts which come in contact with surrounding substances,

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[x] Gall is very philosophical and eloquent in overthrowing the doctrine of excellence of touch being the source of superiority of intellect, and of this sense especially rectifying others and giving us a better knowledge of the external world, ll. cc. 4to. p. 208. sqq. 8vo. t. i. p. 85. sqq. Those who have not read both his large and octavo work may not be aware for what absurdities he had to oppose Buffon, Condillac, Cuvier, Herder, Richerand, Vicq d'Azyr, blind followers of Anaxagoras and Galen.

As *philosophers* have ascribed the superiority of man's intellect to his hand, and of the elephant's to its trunk, the constructiveness of the beaver to its tail, and the ferocity of the tiger to its teeth and claws, the poor man may be excused who was lately executed at Chelmsford, and left the following directions: — "I, Edward Clarke, now in a few hours expecting to die, do sincerely wish, as my last request, that three of my fingers be given to my three children, as a warning to them, as my *fingers* were the cause of bringing myself to the gallows and my children to poverty." The request was complied with by the surgeon. *Examiner*. April 23. 1837.

the more delicate and acute, with an equal supply of nerves, will be the sense. Many without hands, as organs of touch, have other organs to compensate for their absence. "We observe, even from the polygastric animalcules, that organs are developed at the anterior part of the body, which appear to be adapted to communicate sensations corresponding with those of touch in the higher animals. They have long cilia, almost already developed into tentacula; and those tentacula, so common in the class of zoophytes, appear to be endowed with great delicacy of feeling. Those fleshy and sensitive tentacula and tubular feet of the radiated animals continue up through many of the succeeding classes of animals, becoming jointed in the articulated classes, where they form palpi and antennæ; and in the soft molluscous classes they again assume the form and name of tentacula,—soft, sensitive, and fleshy, without any jointed appearance. We observe remnants of those sensitive organs even in the class of fishes in the form of processes or filaments still disposed as organs of touch around the mouth." "Many fishes and higher animals are covered with dense scales which must deaden the general sense of touch over the surface of their bodies: other fishes have the lower part of the head, the lower part of the abdomen, the circumference of the mouth, and other exposed parts, covered with a naked, delicate, and soft integument, which will compensate for the want of development of the arms and hands as organs of touch. But in the land amphibious animals, and in all the higher vertebrata, we observe the anterior extremities to become more delicately organised, and fit for communicating delicate impressions of the forms, densities, and other physical qualities of external bodies; and in proportion to the high nervous sensibility, the vascularity, the flexibility, and the softness of the hands and other external cutaneous parts, will that common sense of touch become increased as we pass up through the vertebrated classes to man, who surpasses all inferior animals in the exquisite and equal development of all his organs of sense, and in the perfection of all those higher organs of relation by which animals are more immediately connected with outward nature." (Dr. Grant's *Lectures. Lancet*, No. 569.)

I presume that the tongue must be considered as an organ of touch as well as of taste; and the snout in the mole and pig; the moist upper lip in the rhinoceros; the proboscis of the elephant; and the lower end of the tails of apes called sapajous. The whiskers of the "feline and other mammalia probably serve to make the proximity of bodies known to the animal. The seal has a very long infra-orbital branch of the fifth pair, with about forty branches, which are distributed to the upper lip, and many of which have been traced by Blumenbach to the roots of the strong whiskers." (*Manual of Comparative Anatomy*, translated by Messrs. Laurence and Coulson, p. 259. sq.)

CHAP. XXIII.

TASTE.

"We perceive tastes by the tongue, and in some degree," says Blumenbach, in conformity with the common opinion, "by the other neighbouring internal cutaneous parts of the mouth, especially by the soft palate, the fauces, the interior of the cheeks, and lips; by them, however, we taste only what is acrid and very bitter[a]:" and Dr. Vimont says that, on touching the lips, inside of the cheeks, and the palate, with a very concentrated solution of common salt, with strong vinegar, and pure alcohol, their respective tastes were not experienced, while he instantly had the taste of each when brought in contact with the upper surface of the tongue.[b]

The most careful and extensive experiments have been made by M. M. Guyot and Admyrauld[c], and they declare the lips, the internal surface of the cheeks, the hard palate, and the pharynx, to be utterly destitute of taste; the soft palate to be also destitute, *except at one spot*, commencing about a line below its union with the hard palate, descending to within three or four lines of the base of the uvula, and extending indefinitely on each side till lost insensibly; and the tongue to be destitute at its lower part and all its dorsal surface. So that the only seats of taste are the small space in the soft palate, that portion of the base of the tongue behind a curved line drawn with its concavity forwards and passing through the blind foramen, and the whole of the circumference of the organ, on the upper part of which the sense extends a little farther towards the middle of the organ, especially near the apex, than on the lower; and the portion at the

[a] "Grew, *Anatomy of Plants*, p. 284. sq.

Petr. Luchtmans, *De Saporibus et Gustu*. L.B. 1758. 4to. p. 58. sqq.

J. Gottl. Leidenfrost, *De sensu qui in faucibus est, ab eo qui in lingua exercetur, diverso*. Duisb. 1771. 4to."

[b] *Traité de Phrén.* vol. ii. p. 138. sq.

[c] *Mémoire sur le Siége du Gout, chez l'Homme*, Paris, 1830.

apex has a more acute taste than the rest of the circumference. These gentlemen remark that the seats of taste, as ascertained by them, are the most favourably placed for the exercise of the sense. Substances have the apex of the tongue applied to them as soon as they are moistened by the lips; the softer portions fall during mastication, some within the alveolar arch in contact with the circumference of the tongue, and others without it, but these are immediately pressed over to the circumference of the tongue by the cheeks; while the food is compressed between the dorsum of the tongue and hard palate, going through a kind of mastication for which the firmness and moderate sensibility of the dorsum render it peculiarly fit, the fluid portions are expressed and run over to the circumference; and, finally, the bolus, when properly moistened and fit for deglutition, is pressed between the base of the tongue and the central gustatory space in the soft palate.

"The chief organ of taste is the *tongue*[d], agile, extremely ready, changeable in form; in its remarkably fleshy nature, not unlike the heart; and endowed with far more excitability than any other voluntary muscle.[e]

"Its integuments resemble the skin. They are, an epithelium, performing the office of cuticle; the reticulum Malpighianum[f]; and a papillary membrane, but little different from the corium.

"The integuments of the tongue differ from the skin chiefly in these respects — in the epithelium being moistened, not by the oily fluid of the skin, but by a mucus which proceeds from the foramen cæcum of Meibomius[g] and the rest of the glandular expansion of Morgagni[h], and, secondly, in the conformation of the papillæ, which are commonly divided into petiolated, obtuse, and conical.[i] The first are in very small number and situated in

[d] "Sömmerring, *Icones Organorum Humanorum Gustus.* Francof. 1808. ol."

[e] "This fact, contrary to the opinion of others, I have proved by dissection of living animals, and by pathological observation. *Specimen Historiæ Naturalis ex auctoribus classicis illustratæ.* Gotting. 1816. 4to. p. 4. sqq."

[f] "In dogs and sheep with variegated skin, I have commonly found the reticulum of the tongue and fauces also variegated."

[g] "Consult Just. Schrader, *Observat. et Histor.* from Harvey's book *De Generatione Animalium.* p. 18[illegible]."

[h] "Morgagni, *Adversar. Anat. Prima.* Tab. 1."

[i] "Ruysch, *Thesaur. Anat.* 1. tab. iv. fig. 6.

B. S. Albinus, *Annotat. Acad.* l. i. tab. 1. fig. 6—11."

a lunated series at the root of the tongue; the others, of various magnitudes, lie promiscuously upon the back of the tongue, and chiefly upon its edges and apex.[k] The tongue is furnished with nerves by the lingual branch of the fifth pair[l]," by the hypoglossal, and the glosso-pharyngeal. The first gives common sensibility; the second, motion; the latter, the sense of taste: as is shown by Dr. Panizza.[m]

The glosso-pharyngeal or gustatory nerve commences by two, three, or more filaments, from the chorda oblongata, at a part of Sir C. Bell's respiratory tract, unluckily, and emerges between the corpora olivaria and restiformia.[n] It has no communication with the other nerves of the tongue: and gives off no muscular filaments. It is distributed to the mucous membrane of the tongue, epiglottis, tonsils, and upper part of the pharynx. It communicates both with the vidian or recurrent pterygoid nerve of the spheno-palatine ganglion, or at least a branch of it runs some way with a branch of this, and with a branch of the facial, or at least runs also with this; for I cannot conceive nerves of sensation and motion really to mingle in their course and form a third nerve, however they may mingle in ganglia or the encephalo-spinal mass or in plexuses, in order that the nerve of sensation may influence the nerve of motion, which must still run on, I imagine, afterwards distinct, as before: it communicates with the pneumono-gastric, superior cervical ganglion, and with the pharyngeal plexus, in all probability for influencing these parts: and we know how great is the sympathy of the organs of taste with the pharynx and stomach, &c.

Blumenbach correctly states that "the ninth pair[o]," "which also supplies the tongue[p], appears intended rather for the various move-

[k] "Consult Haller's excellent description of the tongue of a *living man*, in the *Dictionn. Encyclopédique*. Yverdon, vol. xxii. p. 28."

[l] "J. Fr. Meckel, *De Quinto Pare Nervorum Cerebri*. Gotting. 1748. 4to. p. 97. fig. 8. n. 80."

[m] *Ricerche sperimentali sopra i nervi. Lettera del Professore Bartolomeo Panizza al Professore Maurizio Bufalini*. Pavia, 1834.

[n] Gall, l. c. 4to. vol. i. p. 102.

[o] "J. F. W. Böhmer, *De Nono Pare Nervorum Cerebri*. Gotting. 1777. 4to."

[p] "See Haller, *Icon. Anatom.* fasc. ii. tab. 1. letter g.
Monro, *On the Nervous System*. Tab. xxvi."

ments of the organ, in manducation, deglutition, speaking, &c.[q] But, like most others, he believes that the lingual branch of the fifth pair is for taste; and the glosso-pharyngeal, as well as hypoglossal, for motion.

Professor Panizza has lately demonstrated that the lingual is for common sensibility, and the glosso-pharyngeal for taste. When the hypoglossal was divided by him in a dog or sheep, the tongue instantly lost all motion. If milk was offered, the animal hastily advanced and made the movements of lapping with the head and lower jaw, but the tongue lay motionless in the mouth, and the animal at last gave up all attempts to lap. If soaked bread was offered, he took it into his mouth, and attempted to masticate, but suddenly laid it down, scarcely divided into two pieces, one of which he took up again, subdivided, and treated in the same way, till the fragments were on the ground and abandoned by him. If his tongue rolled out of his mouth, it so remained, and was bitten till he howled again. The tongue no more assisted in the process of deglutition than of mastication. If solid food was placed on the tongue, and did not fall off into the pharynx, between the tongue and the teeth, or out of the mouth, by the motion of the head and lower jaw, it was found there after many hours. If by these motions it tumbled into the pharynx and was swallowed, deglutition was still imperfect, because

[q] Besides the well-known ganglion petrosum of the glosso-pharyngeal nerve, Dr. Müller of Berlin has discovered another ganglion on this nerve in the human subject. He describes it as situated within the cavity of the cranium near the jugular foramen, as being very inconsiderable in size (not more than a millimetre, $\frac{1}{30}$ inch, in length), and as belonging, not to the whole root of the nerve, but only to one of its fasciculi, which fasciculus, he adds, arises from the same region of the chorda oblongata as the rest of the nerves.

Dr. Mayer of Bonn has observed two small ganglia on the root of the glosso-pharyngeal nerve of the ox. Each is placed on a separate fasciculus of the nerve near to but within the place where it pierces the dura mater.

Dr. Mayer has also discovered that the hypoglossal in the ox, dog, and pig has a posterior as well as an anterior root. The posterior root, which is very delicate, arises from the posterior surface of the chorda oblongata, passes over the accessory nerve (without, however, being connected with it) forms a small ganglion, from which it emerges augmented in size, and joins the anterior root. Dr. Mayer has once, but only once, observed this posterior root and its ganglion in the human subject. Dr. Müller could never discover it in man, but has seen it distinctly in the ox. See Müller's *Handbuch der Physiologie*, p. 589., and Dr. Mayer in the *Acta Acad. Cæs. Leop. Nat. Cur.* vol. xvi. p. ii.

the mass, when squeezed by the superior pharyngeal muscle, partly returned into the mouth from the tongue being unable to close the isthmus of the fauces and thus compel it to take altogether a downward course. There was the same difficulty if fluid was poured into the fauces. If the sheep took vegetable substances between its teeth or lips, he could not draw them into his mouth, and his bleat became hoarse and feeble. That the sensibility of the tongue was unimpaired, was shown, if it was pricked near the tip, or base, or at the centre, by the animal howling if he bit it, by the efforts, already mentioned, to dislodge a morsel placed upon it, by his shaking his head with his mouth open to reinstate it if in making the experiments it had been folded back, and by his efforts to vomit, as well as by his expressions of pain, whenever the tongue was pricked at the base. That taste continued, was shown by the disgust expressed whenever a solution of colocynth, which is neither acrid nor odorous, was placed upon the tongue.

When the two lingual branches of the fifth pair had been divided, the animal licked, lapped, ate, and drank as before; and colocynth placed upon its tongue carefully, so as to touch no other part, instantly excited disgust; so that motion and taste were unimpaired, but the tongue might be burnt and wounded in all ways without the animal expressing pain.

If both the hypoglossal and lingual branches were divided, motion and sensibility were lost, but taste still remained perfect.

If the glosso-pharyngeal pair was divided, motion and sensibility were unimpaired, but colocynth and any other nauseous substance that had no smell produced no disgust, and was swallowed with the same avidity as the most agreeable, and the vessel which contained it was licked out clean. A dog, in which the lingual nerves only had been divided, and which was swallowing some meat, swallowed hastily also a piece made bitter, but was seized with vomiting and compelled to disgorge it as soon as it reached the gullet: but the dog in which the glosso-pharyngeal had been divided, ate up the very piece instantly, and gave no sign of finding it disagreeable. Yet this same dog expressed great suffering if his tongue was pricked with a needle.

If the hypoglossal was pinched immediately after death, the tongue moved: but no such effect resulted from pinching the lingual or glosso-pharyngeal nerve. The glosso-pharyngeal, Professor Panizza observes, both in man and brutes, gives no

filaments to the muscles among which it passes, but is wholly distributed to the nervous membrane of the tongue and other parts which are likewise the seat of taste; and its filaments are the most abundant at the base of the tongue, where taste is the most acute.

We are thus gratified at witnessing an uniformity with the other organs of sense. They have one set of nerves for their muscles; another for their common sensibility or touch, and this is the same as that possessed by the tongue, or the trigeminus; and a distinct nerve for their specific sense. Sir C. Bell, having found the glosso-pharyngeal arise in his respiratory tract, called it a respiratory nerve, and made it preside over deglutition; while he considered the lingual to be the nerve of the specific sense, though it does not arise distinctly like the olfactory, optic, and acoustic, but is a mere branch of a nerve of touch — of the trigeminus, which he very properly classes with the double spinal nerves. "The extraordinary part of this speculation is," Dr. Panizza remarks, "that, among the arguments by which the various opinions were supported, the anatomical distribution of each nerve was uniformly adduced; so true it is that prejudice obscures the observation as well as warps the judgment."

"For the tongue to taste properly, it must be moist, and the substance to be tasted must," according to common opinion, "be liquid.[r] For if either is in a dry state, we may perceive the presence of the substances by the common sense of touch, which the tongue possesses in great acuteness, but cannot discover their sapid qualities." It is by no means proved, however, that the moisture indispensable for taste is requisite to dissolve the substance tasted, and not to fit the papillæ for their office; for moisture is secured to the nerves of every sense.

"When the tongue tastes very acutely, the papillæ around its apex and margins seem to be in some degree erected."

Dr. Nehemiah Grew, in a discourse read before the Royal Society in 1675 [s], endeavoured to show that there are at least sixteen different simple tastes, which he enumerates. All these, he avers, have various degrees of intensity and weakness, and may be

[r] "Bellini, *Gustus Organum novissimè deprehensum.* Bonon. 1665. 12mo."

[s] *A discourse of the diversities and causes of tastes, chiefly in plants,* published with all his *Lectures,* by the Royal Society, in one folio volume.

combined together in an innumerable variety of proportions. Many of these have other modifications; "in some the taste is more quickly perceived upon the application of the sapid body, in others more slowly; in some the sensation is more permanent, in others more transient; in some it seems to undulate or return after certain intervals, in others it is constant. All these, and other varieties of tastes, Dr. Grew illustrates by a number of examples."[t] The various parts of the organ, as the lips, the tip of the tongue, the root of the tongue, the fauces, the uvula, and the throat, are some of them chiefly affected by one sapid body, and others by another.

Taste is rendered stronger by pressing the tongue firmly against the sapid substance and moving it. The impression made by a sapid substance is often much influenced by the taste just experienced. The taste of a second substance may be improved or spoiled by the impression of the first: the taste of malt liquor is greatly improved by first tasting cheese. Gall argues against the common opinion, that indulgence deadens the taste, and contends that this renders it more discriminating. He asks if our cooks distinguish sapid articles less perfectly than savages; and if the instances of poisoning among peasants by eating hemlock, belladonna, or poisonous mushrooms, do not prove that their taste is not superior to that of voluptuous citizens? It varies in different persons; at least what is agreeable to one person is disagreeable or indifferent to another; even in regard to mere taste, it is true that "one man's meat is another man's poison." It differs in the sexes, at different ages, and under the influence of habit and of diseases: — men like stronger articles of taste than women; children love sugar more than adults, and dislike fat, which is agreeable to adults; the lower orders enjoy food which would make the higher sick; and chlorotic girls are often fond of mortar and cinders.

Taste is not an unerring index of the wholesomeness of food: for noxious articles are sometimes eaten with pleasure, and wholesome substances disliked.

[t] Dr. Reid, *Inquiry into the Human Mind*, c. 3.

M. M. Guyot and Admyrauld have just published a second memoir in which they illustrate Dr. Grew's remark respecting the effect of different savours on different parts of the gustatory apparatus, and show that its different parts are affected differently by the same sapid body.

When the tongue or interior of the mouth or throat is rather dry, we experience thirst. But, if the dryness is extreme, the nerves may not feel the want of fluid, being apparently disqualified for their office; and merely the roughness of the parts may be complained of. The most intense thirst is felt when the exterior of the tongue and interior of the mouth and throat are covered with a sticky substance: — viscid secretion or jelly will give intense thirst, there being insufficient fluidity and yet no disqualifying aridity.

All animals having a mouth and stomach have probably taste. To disprove a common opinion that birds have but little taste, Gall mentions that Blumenbach finds the organ much larger proportionally in the duck than in the goose; that the palate of many are supplied with very strong and large nervous papillæ; that many birds bruise insects and grains; and many, if different kinds of food are given them, select the most agreeable; that, if whole ants are given to fresh caught nightingales, the birds usually reject them, but if they are bruised they are swallowed with avidity; that those birds which swallow their food whole distinguish different berries and grains with their beak, so that, although all may be taken into the mouth indifferently, the unsuitable are presently rejected; that swans will crush and greedily swallow rats and frogs, but instantly refuse to swallow toads; and that swallows, and all birds that feed on insects, devour bees and large flies, but reject various insects: he reproves M. Duméril for supposing, before the Institute of France, that Nature has supplied fishes with a tongue possessed of a fine membrane, and not given it the sense of taste. Different animals are differently affected by sapid substances: what is disgusting to some is delightful to others; what would make us sick is often a dainty to certain brutes. Gall refutes the absurd opinion of Professor Akerman, that the perfection of man's intellect arises from the perfection of his senses and that man has a finer taste than brutes, by stating that the papillæ of the tongue, pharynx, palate, &c. are proportionally larger and more numerous in brutes; that, to increase the surface of taste, many brutes have the membrane of their palate furrowed and sprinkled with a multitude of nervous papillæ; and that the eating apparatus is in most of them larger than in man; that the dog, bear, and monkey have their tongue covered with as fine a membrane as that of man; and that the enjoyment of taste appears the greatest and most enduring of all in many, as they are eating and ruminating almost constantly while awake. l. c. 4to. vol. 1. p. 151. sqq.

CHAP. XXIV.

SMELL.

"While taste and smell are closely related by the proximity of their organs, they are not less so by the analogy of their stimuli and by some other circumstances. For this reason they have been generally classed together under the name of chemical or subjective senses.

"By smell we perceive odorous effluvia received by inspiration and applied principally to that part of the Schneiderian[a] membrane which invests both sides of the septum narium and the convexities of the turbinated bones.

"Although the same moist membrane lines the nostrils[b] and their sinuses[c], its nature appears different in different parts.

"Near the external openings it is more similar to the skin and beset with sebaceous follicles, from which arise hairs known by the name of vibrissæ.

"On the septum and the turbinated bones it is fungous and abounds in mucous cryptæ.

"In the frontal, sphenoidal, ethmoidal, and maxillary sinuses, it is extremely delicate, and supplied with an infinite number of blood-vessels which exhale an aqueous dew.

[a] "Conr. Vict. Schneider, *De Osse Cribriformi et Sensu ac Organo Odoratus.* Witteb. 1655. 12mo.

This classical work forms an epoch in physiological history, not only because it was the first accurate treatise on the function of smell, but because it put an end to the visionary doctrine of the organ of smell being the emunctory of the brain."

[b] "Sömmerring, *Icones Organorum Humanorum Olfactus.* Francof. 1810. fol."

[c] "Haller, *Icones Anat.* fasc. iv. tab. ii.

Duverney, *Œuvres Anatom.* vol. i. tab. xiv.

Santorini, *Tab. Posthum.* iv.

C. J. M. Langenbeck, *Neue Bibl. für Chirurgie*, vol. ii. P. ii. p. 318. tab. ii."

"It appears the principal, not to say the sole, use of the sinuses[d], to supply this watery fluid, which is perhaps first conveyed to the three meatus of the nostrils and afterwards to the neighbouring parts of the organ of smell, preserving them in that constant state of moisture which is indispensable to the perfection of smell.

"The sinuses are so placed, that, in every position of the head, moisture can pass from one or other of them into the organ of smell.

"The principal seat of smell, — the fungous portion of the nasal membrane, besides numerous blood-vessels, remarkable for being more liable to spontaneous hemorrhage than any others in the body, is supplied by nerves, chiefly the first pair [e], which are distributed on both sides of the septum narium, and also by two branches of the fifth pair. The former appear to be the seat of smell [f]: the latter to serve for the common feeling of the part, that excites sneezing, &c."

The olfactory nerves arise from the pulpy substance at the anterior part of the internal convolutions of the middle lobes,—of course at the base of the cerebrum. The filaments are surrounded a long way with pulpy substance, approach each other, and usually form three roots, which also unite, and where they unite a triangular enlargement is produced: but the nerve soon contracts and runs in a triangular groove at the inferior surface of the anterior lobe on the upper surface of the sphenoid bone. The two nerves converge as they approach the ethmoid, and at last form an oval bulbous expansion, containing a great deal of grey pulpy substance on the cribriform plates. From this soft bulb

[d] "In my *Prolus. de Sinibus Frontal.*, Gotting. 1779. 4to., I have brought forward many arguments from osteogeny, comparative anatomy, and pathological phenomena, to prove that these sinuses contribute indeed to the smell, but little or nothing to voice and speech, as was believed by many physiologists."

[e] "Metzger, *Nervorum Primi Paris Historia.* Argent. 1766. 4to. reprinted in Sandifort's *Thesaurus*, vol. iii.

Scarpa, *Anatomic. Annotat.* l. ii. tab. i. ii."

[f] "This is shown by pathological dissection and comparative anatomy. Thus in Loder's *Observ. Tumoris Scirrhosi in Basi Cranii reperti*, Jen. 1779. 4to. is a case of anosmia, following a compression of the first pair by a scirrhus. We learn, from comparative anatomy, that in the most sagacious mammalia, *v. c.* elephants, bears, dogs, bisulcous ruminants, hedgehogs, &c., the horizontal plate of the cribriform bone is very large, and perforated by an infinity of small canals, each of which contains a filament of the olfactory nerve."

numerous fine branches proceed through the foramina of the bone.

"The extreme filaments of the first pair do not terminate in papillæ, like the nerves of touch and taste, but deliquesce, as it were, into the spongy and regular parenchyma of the nasal membrane.

"The organ of smell is very imperfect and small at birth. The sinuses scarcely exist. Smell consequently takes place but late, — as the internal nostrils are gradually evolved; and it is more acute in proportion to their size and perfection.[g]

"No external sense is so intimately connected with the sensorium and internal senses, nor possess such influence over them, as the sense of smell.[h]

"No other is so liable to idiosyncrasies, nor so powerful in exciting and removing syncope.

"Nor is any other capable of receiving more delicate and delightful impressions; for which reason, Rousseau very aptly called smell, *the sense of imagination.*[i]

[g] "While animals of the most acute smell, as those just mentioned, have the nasal organs most extensively evolved, precisely the same holds in regard to some barbarous nations.

Thus, in the head of the North American Indian (a leader of his nation, and executed at Philadelphia about fifty years ago), which I have given in my *Decas prima Collectionis Craniorum diversarum Gentium illustratæ*, tab. ix., the internal nares are of an extraordinary size, so that the middle of the ossa spongiosa, for example, are inflated into immense bullæ, and the sinuses, first described by Santorini, which are contained in them, larger than I have found them in any other instance.

The nearest to these, in point of magnitude, are the internal nares of the Ethiopians, from among whom I have eight heads, now before me, very different from each other, but each possessing a nasal organ much larger than we find it described to be in that nation by Sömmerring, *über die körperl. Verschiedenh. des Negers*, &c. p. 22.

These anatomical observations accord with the accounts given by most respectable travellers concerning the wonderful acuteness of smell possessed by those savages.

Respecting, *v. c.* the North American Indians, consult, among others, Urlsperger, *Nachr. von der Grossbritann. Colonie Salzburg. Emigranten in America*, vol. i. p. 862.

Respecting the Ethiopians, *Journal des Sçavans.* 1667. p. 60."

[h] "See Alibert on the medical power of odours, *Mém. de la Soc. Médicale*, t. i. p. 44."

[i] "*Emile*, t. i. p. 367."

"No sensations can be remembered in so lively a manner as those which are recalled by peculiar odours." [k]

Haller mentions that less than the two billionth part of a grain of camphor has been distinctly odorous. [l]

The causes of the sensation of smelling are, as yet, unknown, and in the absence of positive knowledge on this subject philosophers have either avowed their ignorance or contented themselves with hypotheses destitute of proof. Among the opinions respecting these recondite phenomena which have at various times been advanced, three may merit our consideration. The advocates of the first designate by *spiritus rector*, or *aroma*, a principle independent of the substances which contain it, very volatile and expansible, imponderable, and imperceptible to every sense excepting that of smell: and to the various modifications of this immaterial substance they attribute the varieties of odour. The second, and most generally received theory, is that odours are particles which evaporate from the odorous substance itself, and that the cause of the sensation of smell is therefore inherent in, and inseparable from, the odorous body. The third opinion, which is maintained by Professor Walther, is, that olfaction is independent of the emanations of material particles and is a simple dynamic action of the odorous body upon the organs of smelling, similar to the action of sound on the hearing.

However this may be, odours, to become objects of sensation, must pass the pituitary expansion of the olfactory nerve during the respiratory process. When the breath is held, the most odorous substances may be spread in the interior of the nostrils without their perfume being perceived; this observation was first made by Galen. It has been frequently remarked that odours are smelt only during inspiration, the same air when returned through the nostrils always proving inodorous. But this is true only when the odour has been admitted from without by the nostrils, for, when it is admitted by the mouth, as in combination with articles of nutrition, it can be perceived only during *expiration*. A proof of this may be readily obtained by placing the open neck of a small phial, containing an essential oil, in

[k] "Respecting the power of smell over morals and propensities, consult Benj. Rush, *Medical Inquiries and Observations*, vol. ii. p. 34."

[l] *El Physiol.*, vol. v. p. 157.

the mouth during the acts of inspiration and subsequent expiration.

It was first observed by Willis [m] that, on placing a sapid substance in the mouth, and at the same time closing the nostrils, the sensation of taste is suspended. This observation has since been frequently repeated, and has given rise to the generally prevailing opinion that a very intimate relation exists between the sensations of smelling and tasting, and that the same qualities of bodies simultaneously affect both these senses. The fact is that the causes of taste and smell are totally distinct in their nature. Tastes, properly so called, affect only the gustatory expansion, and are, consequently, unaltered by closing the nostrils; but, as most sapid substances have also an odour, and expiration takes place frequently during mastication and generally directly after deglutition, the odorous emanations are made to pass over the pituitary membrane. Odour, which thus accompanies taste, is termed *flavour*.

Sugar, salt, and vinegar, have each a real taste, which can be affected neither by catarrh, palsy of the olfactory nerves, nor by stopping the nostrils; but the flavour and odour of roast meats, of spices, of liqueurs, &c., are identical, and they are affected equally by the same conditions.

Dr. Prout, I believe, was the first who pointed out the distinction between taste and flavour.[n] He conceived, however, that flavour was intermediate between taste and smell.

I have seen instances of the loss of smell from a fall on the head, and other violent causes. Whatever had no odour could be tasted as usual: but the mechanical and pungent qualities only of simply odorous bodies habitually taken into the mouth could be perceived; and bodies both odorous and sapid were tasted only, and therefore but imperfectly judged of.[o]

Some tribes of uncivilised men far surpass us in the power of smell. The American Indians have distinguished men of different nations by this sense. Dogs readily distinguish individuals by its means, and in many brutes of prey it is very powerful.

[m] *De anima brutorum.* By Thos. Willis, M. D. 1672.

[n] *London Med. and Physical Journal.* 1812.

[o] I was consulted by a tea-broker who lost his smell from a fall on his head, and could no longer judge of teas. He went through the form of tasting teas at the East India House, that his inability might not be suspected, but he was totally insensible to their flavour. He tasted salt and sugar as well as ever.

Angelo Poliziano says that after a battle a flock of famished vultures arrived the next day from a distance of 166 leagues to devour the bodies. But Mr. Audubon relates two experiments to show that vultures are indebted to acuteness of sight rather than of smell. He stuffed a deer's skin with hay, allowed it to become as dry as leather, and placed it in a field: in a few minutes a vulture made for it, attacked it, tore open the stitches, and pulled out the hay. He then put a large dead hog into a ravine, and concealed it with cane; it putrefied and gave forth an intolerable stench, but the vultures which were sailing about in all directions in search of food never discovered it, although several dogs had been attracted and had fed plentifully on it. He next stuck a young pig and covered it closely with leaves: vultures soon saw the blood, descended to it, and by its means discovered the pig, which they devoured while still fresh.

Whenever smell is naturally powerful, the organ and olfactory nerves are greatly developed. In disease it may become surprisingly acute. T. Bartholin mentions an individual, labouring under dropsy, who could name the individuals in the next room by smell.[p] The boy Mitchel, deaf and blind from his birth, is described by Mr. Wardrop as having, probably from great use and attention, so powerful a sense of smell, that, "when a stranger approached him, he eagerly began to touch some part of his body, commonly taking hold of the arm, which he held near his nose, and after two or three strong inspirations, appeared to form a sudden opinion regarding him. If this was favourable, he showed a disposition to become more intimate, examined more minutely his dress, and expressed by his countenance more or less satisfaction: but, if it happened to be unfavourable, he suddenly went off to a distance, with expressions of carelessness or of disgust."[q]

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[p] *Acta Hafniensia.* However, in the same work (vol. i.) it is related by a Dr. Marcus Marci, on his own testimony, that a priest at Prague could distinguish incorrect from correct ladies by his nose. Yet this was not worse than the declaration in London, a few years ago, of a once extensively employed insanity doctor, that he could distinguish madmen by his nose, — that madmen do not smell like other people.

[q] *History of James Mitchel, &c.* By James Wardrop. London, 1813.

All animals exposed to the air have perhaps the sense of smell. Its seat has been referred in the air-breathing annelides and insects to the mouths or lateral pores of the air sacs; or in the latter "to the delicate extremities of their long flexible antennæ, and the inner pair of those organs in the crustacea have been considered as the seat of the same sense. The labial appendices of the conchifera, the entrance to the respiratory sacs of pulmonated gasteropods, the highly sensitive tentacula covered with a delicate mucous membrane, and even the whole surface of the skin in the more elevated molluscous classes, have been considered as the organs through which these animals receive impressions from odorous emanations. In the class of fishes, we observe the organ of smell to be only a depression excavated on the anterior part of the face, but it does not communicate behind with the mouth, or the respiratory organs, or the interior of the body." "By the motions of fishes through the water they are sufficiently exposed to receive impressions of odorous substances diffused through that medium, without drawing dense water through those delicate organs for the purposes of smell. Perhaps the volumes of water necessary to be carried continually through the mouth of fishes for respiration are too great, and would prove too powerful a stimulus to have passed through such an organ of smell, and to have allowed that organ to preserve its necessary delicacy, and therefore it is quite apart from the passage through which that element is taken for respiration in all water-breathing animals. It is, obviously, however, in fishes an organ of great delicacy and importance, and is of great size, provided with very large olfactory nerves, and large olfactory tubercles, coming off alone from the hemispheres of the brain." "In the amphibious animals, where the respiration of air begins to take place through the nostrils, the olfactory apparatus begins to be more complicated and concealed." In fish a plate of cartilage sometimes divided the impervious olfactory cavity into two: in the amphibia this "begins to assume now the more compact and convoluted form which the osseous plates in the higher animals present. The surface of the organ thus increases in extent, as we ascend through the reptiles and through the birds to the mammalia. In the perenni-branchiate amphibia the nostrils form still on each side a simple sac, scarcely complicated internally, and having their posterior opening so far formed in the mouth as to be immediately under the upper lip. In the salamanders and frogs the nostrils are still, in the larva state, confined to the exterior of the head, as in fishes; but in the adult form, the posterior openings, though within the cavity of the mouth, are still much advanced in their position, and remote from the median line." "In the serpents the internal surface is extended by the rudimentary turbinated bones, and by an enlarged nasal cavity, opening posteriorly by a common orifice on the median line." "In the sauria the turbinated bones begin to be strengthened by ossific matter and to assume a more complicated form: both the anterior and posterior openings of the nares present enlarged dimensions, and the whole organ is more internal and more protected by the expanded nasal bones. The organs of smell are more protected and concealed in the solid head of the chelonian reptiles, where their surface is increased in extent and their posterior openings are placed further back from their primitive anterior aspect. The anterior openings of the nostrils are here

very small. The olfactory nerves, and the whole organs of smell, are small in birds. The anterior openings are large and oblique for respiration during their rapid movements, and the various forms and positions of these apertures present useful characters for the distinction of species. The turbinated bones are larger than in reptiles, though still but partially ossified, and the olfactory nerves pass through the orbits into the nose. The defective development of this organ is compensated for in some by the extensive distribution of its fifth or trifacial nerves, on the upper and lower jaws, and in most by the great development of the organs of vision. All the internal parts of the organs of smell become more complex and elaborate in quadrupeds, new cavities open into their interior, as the frontal, maxillary, and frontal sinuses, and the exterior nares assume a more lengthened and expanded form. Most of these animals we observe to have all the nasal cancellated bones of great size and presenting an immense surface, both on the ethmoid and turbinated bones, for the distribution of the olfactory nerves, and we perceive in them a corresponding increase of power in their sense of smell." (Dr. Grant's *Lectures. Lancet*, No. 569.) Gall refuted the assertion of Cuvier and others, that carnivorous brutes have a more acute smell and larger olfactory nerves than the herbivorous; and thus replies to M. Duméril's opinion of odours not being transmissible by water, and of the organ of touch occupying that of smell in the cetacea. "Nature then has made a mistake in placing one of the special organs of animals that live in water, and amused herself with this prank when she formed otters, seals, and all fish, and henceforth all attempts to catch fish and crabs with odorous bait will be fruitless." l. c. 4to. vol. i. p. 158. sq.

CHAP. XXV.

HEARING.

By Hearing we are able to appreciate the vibratory motions of elastic bodies, when their frequency is within certain limits. Some experiments by Dr. Wollaston prove that these limits vary in different individuals; but the average extent of the scale of sounds perceptible to the human ear has been estimated to be between 30 and 12,000 vibrations of the sonorous body per second.

The undulations to which these vibrations give rise may be transmitted through any substance, either aëriform, liquid, or solid: but the air is the ordinary medium by which they reach the ear. The velocity of transmission depends on the specific elasticity of the substance; according to the latest experiments, sound travels through air at the rate of about 1142 feet per second.

With regard to the sensation of sound, three independent qualities must be distinguished: [a]

1st. The *tune*, or *pitch;* which depends on the frequency with which the vibrations succeed each other.

2d. The *loudness*, or *intensity;* which is determined by the amplitudes of the vibrations.

3d. The *timbre:* — For this word, adopted in France to express the specific differences of sound which are not comprehended in any of the preceding definitions, there is no analogous term in our language; nor have we at present the least idea of the true causes of these modifications of sound. In some cases the indefinite expression *quality of tone* is employed.

When two or more sounds are heard simultaneously, or successively, the mind by a peculiar faculty perceives the relative fre-

[a] C. Wheatstone, *Experiments on Sound. Annals of Philosophy.* New Series, vol. vi. p. 81.

quency and coincidences of the vibrations. Two sounds are regarded as consonant, when the ratio of their vibrations is very simple; and as dissonant, when the ratio is more complex. The rules which determine the most agreeable successions and combinations of sounds constitute the science of music.

The power of appreciating musical combinations, and consequently the pleasure of listening to them, depends upon a mental faculty seated in a particular portion of the brain, and not upon the acuteness of hearing. A person of the quickest ears may have no music in his soul, and persons of dull ears have often a good *ear for music*. Many authors have ascribed perception of the musical qualities of sounds to the ear, although there is no relation between acuteness of hearing and musical talents. The ear merely presents the sounds, an inward sense perceives their musical qualities. This inward sense resides in a particular portion of the brain, and is proportionate to the perfection of its organisation and size. In all the cases, which I have examined, of flatness or depression of the part of the forehead corresponding to this, the perception of music has been defective; and, in all instances of good musical talent, this part has been full or prominent. The examination of singing birds proves the same thing. Others have with equal absurdity ascribed the idiotism of some persons born deaf to their defect of hearing. Persons may be both idiotic and deaf: but the defect of intellect depends upon the defect of the superior anterior parts of the brain, in quality or quantity.[b]

The organs of hearing are situated at the two sides of the head, in a portion of the temporal bone, which is considered the hardest in the human body. The parts which constitute these organs are the external ear, the meatus auditorius, the tympanum, and the labyrinth.[c] The last named part is, there can be little doubt, the seat of sensation, and the other parts serve only to communicate to the labyrinth the impressions from the sonorous agitations of the air.

The *external ear*[d] is a shell-formed cartilage having various elevations and depressions. This appears destined to collect and

[b] On both these errors, see Gall, l. c. 4to. vol. i. 161. sqq. See also l. c. 8vo. t. v. p. 96. sqq.

[c] "Sömmerring, *Icones Organor. Humanor. Auditus.* Francof. 1806. fol."

[d] "B. S. Albinus, *Annotat. Academ.* l. vi. tab. iv."

reinforce the sound. It is furnished with several muscles for the purpose of changing its form ; but few individuals have the power of using them. It is generally supposed that the habit has been lost in most persons from the earliest infancy, on account of the pressure of the coverings of the head. Be this as it may, some persons preserve the power of controlling these muscles, and I have myself seen an individual in whom the motions arising from their action were perfectly voluntary.[e]

The *meatus auditorius* is partly cartilaginous and partly bony. It is lined by a bitter cerumen.[f] The external ear becomes tubular, and thus continues to the osseous part, where it is terminated by the *membrane of the tympanum*, the office of which is to receive impressions from the agitations of the air, in order to transmit them to the internal ear.[g] The membrane of the tympanum is of an irregular conical form, something like a Chinese hat; its concavity is on the outside, and its projecting point on the inside. It is fixed to a bony rim which is called its frame.

The cavity of the *tympanum* occupies the space between the membrane and the labyrinth. It is an irregular cavity, nearly hemispherical; it is filled with air and communicates with the back part of the mouth by means of a canal called the *Eustachian tube*.[h] The side which is opposite the membrane presents an ob-

[e] " V. J. Rhodius ad Scribon. Largum. p. 44. sq.

J. Alb. Fabricius, *De Hominibus ortu non differentibus.* Opuscul. p. 441.

Ch. Collignon, *Miscellaneous Works.* Cambridge. 1786. 4to. p. 25. sq."

[f] " Consult J. Haygarth, *Med. Obs. and Inquiries*, vol. iv. p. 198. sq."

The cerumen consists, according to Vauquelin, of albumen, which, when burnt, yields soda and phosphate of lime, a colouring matter, and a very bitter inspissated oil strongly resembling the peculiar matter of bile. Cicero explains one use of the cerumen :— " Provisum etiam, ut, si qua minima bestiola conaretur irrumpere, in sordibus aurium, tanquam in visco, inhæresceret." (*De Natura Deorum*, l. ii.) The same applies to particles of dust. Its extreme bitterness, too, deters insects from advancing.

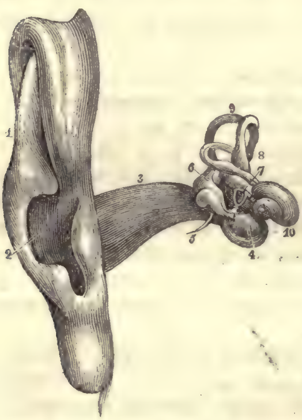
[g] " See the distinguished Himly's acute comparison of the organs of hearing and vision, *Bibliothek für Opthalmologie*, vol. i. p. 6. sqq."

[h] " Saunders, *Anatomy of the Human Ear*. Lond. 1806. fol. tab. i. ii."

" Comparative anatomy renders it most probable that the Eustachian tube is subservient to the action of the membrana tympani. It is found in all red-blooded animals which possess a membrana tympani, but is wanting in fishes which are destitute of this membrane. The different opinions of the moderns respecting its use may be found in Reil's *Archiv für die Physiol.* t. ii. p. 18., iii. p. 165., iv. p. 105., viii. p. 67., ix. p. 320."

lique projection, called the promontory; above this projection there is an opening of the labyrinth called the *fenestra rotunda*[i], and which is shut by a membrane; below, there is another aperture of the labyrinth, the *fenestra ovalis*, where the impressions of the vibrations upon the membrana tympani are communicated to the labyrinth, by a very flexible intermediate apparatus, consisting of a chain of *four small bones*[k], —the malleus or hammer, the incus or anvil, the lenticular bone, and the stapes or stirrup.

The *hammer* consists of a long and thin handle, the extremity of which adheres to the membrane of the tympanum; and of a head, which forms an angle with the handle and is articulated with the anvil. It is united to the bony rim of the membrane by its spinous process, which may be regarded as the fixed point of the lever. The *anvil* is on one side articulated with the head of the hammer; and the opposite part has two processes, one of which serves as a resting point, and the other is articulated by means of the *lenticular bone* with the stirrup. The *stirrup*, which is so called from its close resemblance in form to that object, makes almost a right angle with the anvil, and its moveable base closes the fenestris ovalis of the labyrinth, the interior of which it agitates



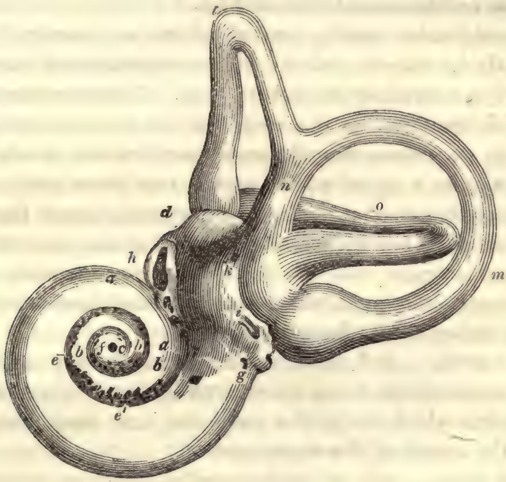
1. External ear.
2. A part of it called concha; and orifice of the meatus externus.
3. Meatus externus.
4. Membrana tympani.
5. Malleus.
6. Incus.
7. Stapes and os lenticulare.
8. Vestibule.
9. Three semicircular canals.
10. Cochlea.

[i] "Scarpa, *De Structura Fenestræ Rotundæ*, &c. Mutin. 1772. 8vo."

[k] "The existence of a fourth bone (called *lenticular*), commonly admitted since the time of Franc. Sylvius, I have disproved at large in my *Osteology*, p. 155. sq. edit. 2. It is wanting in the greater number of perfect examples from adults."

by its pressure. The hammer is provided with three muscles the stirrup only with one, and the anvil has none.[l]

There can be no doubt that the use of this apparatus is to enable us to hear more perfectly: but there are instances in which the hearing has remained after the destruction of these organs. Sir A. Cooper has recorded such cases [m]; and deafness has even been suspended, for a short time, by perforating the membrana tympani. In these cases the sound appears to be transmitted to the laby-



a a a, first turn or gyration of the cochlea.
b b b, second turn.
c, third turn.
d, very short canals for the entrance of nerves.
e e, other holes for the passage of nerves and blood-vessels to the internal ears.
f, canal in the base of the cochlea for the passage of a nervous twig to the infundibulum.
g, portion of the aqueduct of the cochlea.
h, canal for the passage of the nerves of the elliptic vesicles of the superior vertical and horizontal semicircular canal.
i, opening for the passage of the nerves of the inferior semicircular canal, and the nervous flabelliform expansion.
k, aqueduct of the vestibule.
l, superior vertical semicircular canal.
n, inferior vertical semicircular canal.
u, canal produced by the junction of the two vertical semicircular canals.
o, horizontal semicircular canal.

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l " B. S. Albinus, *Tabulæ Muscul.* tab. xi. fig. 29."
m *Phil. Trans.* 1800.

rinth by the immediate action of the air upon the membrane of the fenestra rotunda, which Scarpa calls the secondary membrane of the tympanum.

The *labyrinth*, so called on account of its complicated canals, s the internal part of the organs of hearing, and is hewn out of the hardest portion of the temporal bone. It contains the substance of the auditory nerves, variously spread as layers and fibres in a gelatinous water. Its parts are the three semicircular canals, the vestibule, and the cochlea.

The *semicircular canals*, two of which are vertical, and the third nearly horizontal, contain similar membranous canals, each of which has a swelling at its extremity. These canals terminate by their extremities in the vestibule or central cavity. The cochlea, in part osseous and partly membranous, winds round a conical axis, in a spiral which makes two turns and a half and which diminishes so that the cochlea approaches to the globular form. One of its two gyrations terminates at the fenestra rotunda, which communicates with the cavity of the tympanum; the other proceeds to the vestibule, which itself communicates with the same cavity by means of the fenestra ovalis.

" The vestibule and semicircular canals loosely contain very delicate membranous bags, discovered by the celebrated Scarpa: viz., two sacs which lie in the vestibule, and three semicircular ducts in the canals of the same name.[n]

" These sacs, as well as the cavity of the cochlea, contain a very limpid fluid, bearing the name of Cotugno, who showed it to be absorbed by two canals, which are by him denominated *aqueducts*[o], and by Meckel *diverticula*[p]: the one arises from the vestibule, the other from the inferior scala of the cochlea.

" The portio mollis of the seventh" pair or acoustic nerve arises from the fore-part of the floor of the fourth ventricle, is at first soft, but soon becomes firmer and more fibrous, and, " having, together with the portio dura (which afterwards runs along the *aqueduct* of Fallopius[q]), entered the internal acoustic opening, transmits its medullary filaments into the lower and cribriform

[n] " Scarpa, *Disquisitiones Anatomicæ de Auditu et Olfactu*, tab. iv. fig. 5. tab. vii. fig. 3."

[o] " Cotunni, *De Aquæductibus auris humanæ*. Neap. 1761. 4to."

[p] " Ph. Fr. Meckel, *De Labyrinthi auris contentis*. Argent. 1777. 4to."

[q] " Fallopius, *Observ. Anat.* p. 27. b. sq. Venet. 1561. 8vo."

part of it.[r] These filaments run partly to the vestibule and semicircular canals, but especially to the base of the cochlea, where, in the form of a medullary zonula, marked by very elegant plexiform striæ, they pass between the two laminæ of the septum cochleæ [s]," forming according to Mr. Swan, a net-work, and beautifully terminating in a still more fibrous expansion than the optic nerve.

The facial nerve enters the internal auditory canal in company with the acoustic, which it leaves, and passes through the aqueduct of Fallopius to come out at the foramen stylo-mastoideum. In the aqueduct it gives a filament to the little muscles within the ear. The posterior branch or Vidian nerve of the superior maxillary of the trigeminum, after entering the aqueduct of Fallopius and lying in contact, but not anatomosing with, the facial, gives off a nerve which traverses the tympanum under the name of chorda tympani, and leaves the cranium at the glenoidal fissure. Thus the ear, like the eye and the tongue, has nerves of special sense, of simple sensibility, and of motion.

Notwithstanding the scrupulous examination of the construction of the organs of hearing by anatomists, very little that is certain is known with regard to the uses of the various parts. It is true that many theories have been advanced, but they have for the most part been founded upon analogies which in the present state of acoustic science will not bear investigation.

The hypotheses of M. Savart, which have in general been suggested by accurate experiments, are the most rational which have hitherto been proposed, and the following are the conclusions at which he has arrived from his experiments.

1st. That it is not necessary to suppose, as hitherto has been done, the existence of a peculiar mechanism to bring the membrane of the tympanum continually in unison with the sonorous bodies which act upon it; since it is obviously always in those conditions which render it capable of being influenced by any number of vibrations whatever. 2dly. That its tension probably only varies to augment or diminish the amplitude of its excursions, as Bichat had conjectured: this eminent physiologist,

[r] "Consult Brendel, *Analecta de Concha auris humanæ.* Gotting. 1747. 4to. The same, *De Auditu in apice conchæ,* Ib. eod. 4to."

[s] "Consult Zinn, *Observ. Botan.* Gotting. 1753. 4to. p. 31. sq. Scarpa, l. c. tab. viii. fig. 1, 2."

however, supposed that it was stretched for intense impressions, and relaxed for the weaker, which is contrary to what is demonstrated by experiment. 3dly. That its vibrations are communicated without alteration to the labyrinth by means of the chain of small bones, in the same manner as the vibrations of the belly of a violin are communicated to the back by means of the sound post. 4thly. That the small bones have also for their function to modify the amplitude of the excursions of the vibrating parts of the organs contained within the labyrinth. And lastly, That the cavity of the tympanum probably serves to maintain, near the openings of the labyrinth and the internal surface of the membrana tympani, an air the physical properties of which are constant.

Weber has endeavoured to explain the use of the cochlea. He remarks that sound is propagated through, not only the meatus auditorius externus, but the bones of the head; and, indeed, more distinctly through them. If both ears are stopped firmly with the fingers, our own voice becomes more loud and distinct. If we remove one finger immediately, we hear our own voice stronger with the other ear. If a musical sounding fork under vibration is placed between the teeth, the lips closed and both ears stopped, its tones are heard louder than if the ears were open: open one ear, and the sound is lessened to that ear. If the fork is applied to the left temple and the right ear only closed, the sound is louder to the right ear than to the left which is open. Now sounds propagated through one uniform medium, fluid or solid, lose but little of their force; whereas in passing from one medium to another, as from a fluid to a solid or *vice versâ*, they lose much of their force. In the shaft of a mine the sound of a hammer in a neighbouring shaft is heard very well if the ear is placed in contact with the rock; if this is not done it is heard less, and the sound of voices in the other shaft not at all. Sounds transmitted through water may be heard at great distances if the head is under water; and are inaudible as soon as the head emerges. The effect of a window in lessening the noises of the street is a similar instance Now the sonorous vibrations which pass from the air through the bones of the head to the internal ear will act on the cochlea, because it is the nearest and has its share of the acoustic nerve in intimate contact with itself, and is both osseous and forms a portion of the osseous communication between the mouth and the internal

ear. The vibrations proceeding from the air within the mouth cannot be transmitted so easily to the branches of the acoustic nerve distributed to the vestibule and semicircular canals, because these, spread out as a sacculated and tubular membrane, are studiously separated from the bones by a liquid secretion or loose cellular membrane. Weber therefore concludes that the cochlea is intended to place the extremities of the acoustic nerve in connection with a vibrating solid. On the other hand, he concludes that the use of the semicircular canals is to be in connection with a vibrating fluid and receive the impulses of the air through the meatus auditorius. Because, 1. the vestibule and semicircular canals have a solid communication by the chain of bones with the membrana tympani, whose vibrations are at once imparted by them to the membrana of the fenestra ovalis; whereas there is no such direct communication between the membrana tympani and the fenestra rotunda. 2. The membrane of the semicircular canals and vestibule seem more easily thrown into vibrations by the fluid around them than the lamina spiralis of the cochlea. The latter also, however, is enabled to receive impulses from the air, by the membrane of the fenestra rotunda communicating the vibrations which occur in the tympanum, and by the opening of the cochlea into the vestibule causing the vibrations of the fluid of the vestibule to be at once propagated to the cochlea.

Weber states that Scarpa was the first to discover the remarkable difference in consistence and texture which exists between that portion of the acoustic nerve which supplies the cochlea, and that which is distributed to the vestibule and semicircular canals. The latter, surrounded on all sides by a fluid, are soft and pulpy, evidently fitted to receive impulses from a fluid: the former, on the contrary, fine and ramified, as evidently adapted to the reception of vibrations from a solid.

I must state that Professor Wheatstone above ten years ago made experiments similar to those of Weber and with the same results.[t] His views respecting the functions of the semicircular canals differ from those advanced by Weber. He maintains that

[t] See his Experiments on Audition in the *Journal of Science*, New Series, vol. ii. p. 67. 1827. Some curious and original observations and experiments will be found in a paper by Dr. Wollaston, *Phil. Trans.* 1820; and some interesting facts in Savart's *Memoir*.

sounds are transmitted to the internal organs of hearing in two manners; first, in the manner ordinarily understood, and secondly by the solid part of the head.

The perception that we have of the direction of sounds he supposes to arise solely from the portion which is transmitted through the solid parts of the head, and which, affecting the three semicircular canals, situated in planes at right angles with each other, with different degrees of intensity according to the direction in which the sound is transmitted, suggests to the mind the corresponding direction. If the sound is transmitted in the plane of either of the semicircular canals, the nervous matter in that canal will be more strongly acted on than that in either of the other two; and if it be transmitted in any plane intermediate between any two of the rectangular planes, the relative intensities in these two canals corresponding therewith will vary with the direction of the intermediate plane. The ordinary notion respecting our perception of the direction of sound is that we compare the relative intensity of the sensation in the two ears, and thus judge of its direction. Were this true, a sound produced any where in the prolongation of the mesial plane, whether before, behind, or above the head, should suggest no difference of direction; whereas we know from experience the contrary to be the case. The views of Professor Wheatstone were first announced in Mr. Mayo's lectures at the College of Surgeons.

As most of the lower invertebrate animals live in water, the percussions of which must powerfully effect their surface, naturalists do not find a special organ for hearing among them, till they ascend as high as the air-breathing insects. In these it is more complicated than in any other invertebrata, for many of them emit sounds intended to be heard by their kind. Some have hard instruments for this purpose which they rub against each other, and thus the male and female correspond in the dark for their amours. Insects have not only the first elements of an ear, — the auditory nerve and vestibule, but the rudiments of two semicircular canals: fluid exists within, and the vestibule has a fenestra ovalis covered with a thin membrane. But in the aquatic invertebrata, as the lobster, cray-fish, and crab, the nerve and vestibule with its fenestra ovalis and membrane only are found. In those which have long tails and swim briskly, like the two former, the membrane is delicate and vibratile, whereas in those

which move slowly and have all their organs of sense dull, like the latter, it is dense, and in the crab distinctly ossified. The fixed and slow moving mollusca, as the oyster, barnacle, muscle, slug, snail, have dull senses in general; and their organ of hearing has not been detected, but some appear to hear, and one, — the tritonia arborescens, emits audible sounds, intended no doubt to be heard by its own kind. The cephalopods, however, as the cuttle-fish and nautilus, approaching to fishes in complexity of structure, quickness of motion, and acuteness of sight, have also a higher development of the organ of hearing. We first find a calcareous substance in the fluid of the vestibule, acting probably like the clapper of a bell. "In passing up through the vertebrated classes, we observe the organ gradually developing the semicircular canals and cochlea, and becoming enveloped in the solid parietes of the cranium; it acquires a tympanic cavity communicating with the fauces by the Eustachian tube, and containing the ossicula auditus, which convey the vibrations of the membrana tympani to the vestibule and the whole internal labyrinth; and in the highest forms of the organ a still more exterior meatus auditorius, and complicated moveable concha are added to complete the instrument." Thus, although in the lowest cyclostome or cartilaginous fishes, as the lamprey, the ear is of no higher order than in the cephalepodous mollusca, without canals or calcareous substance, the osseous fishes have calcareous bodies in the vestibule, and large semicircular canals ending in considerable ampullæ. Still the organ is in the common cranial cavity, and not enclosed in the temporal bone, nor are there usually a meatus and external opening. In the large cartilaginous fishes, as the sturgeon and the rays, the ear is imbedded in the cartilaginous temporal bone: in the former the semicircular canals only, the vestibule being still in the cranial cavity; in the latter the whole: and the vestibule has sacs which are the rudiments of a cochlea. The lowest reptiles resident in water, — the perenni-branchiate species, as the newt, have ears like those of fishes, and sounds are equally communicated through the solid walls only of their cranium. The same structure exists in the larva of the caducibranchiate, as tadpoles; but, when the animal loses its gills and becomes a frog, the semicircular canals are imbedded in a distinct cavity of the temporal bone, a tympanum, Eustachian tube, and three soft ossicula united are seen, and the skin forms a membrana tympani on a level with the surface of the head. In the serpents the ear is much the same. In the saurian reptiles the tympanum is much larger. In the crocodile there is an appendage like a rudiment of a cochlea, and on the margin of the membrana tympani two folds of skin, like eyelids, are found, which appear like the rudiments of a concha. In the chelonia, as the tortoise, the tympanum and united bones are of greater length, and a cochlea is more distinctly developed. In birds, the organ is greatly advanced, and large in proportion to the head. It is completely enveloped in bone of rocky hardness; the semicircular canals are smaller than in fishes, but with larger ampullæ; the vestibule is lengthened; the cochlea begins to assume a spiral form, though it still has a remnant of the calcareous bodies found in the labyrinth of fishes; the tympanum is lengthened, and numerous cranial cells communicate with it; a short meatus externus appears; and in nocturnal predaceous birds, which much require the sense of hearing, a high crescentic fold of skin is found at the upper

and back part,—as a rudimentary concha; and the feathers are so arranged around as to serve the purpose of a concha: and this feature is very characteristic in owls. In mammalia all the parts acquire their full development. The cochlea, the size of which bears a pretty constant proportion to the acuteness of hearing, is greatly developed, turbinated, and divided: the ampullæ are often small: the ossicula are first completely developed, are articulated, and supplied with muscles: the Eustachian tube is lengthened; so likewise is the meatus externus, and provided with hairs and a disagreeable secretion for defence; and the concha, the size and mobility of which indicate acute hearing, is developed in this class only, though frequently small or absent in the inferior species and the aquatic, as whales, beavers, and seals. In the timid, which are to be pursued, both it and the meatus are directed backwards; in the predaceous, which are to pursue, forwards: in the former too it is large, and the brain is small; in the latter small, and the brain is large: in the quadrumana, and especially in the oran-outang, it becomes short, round, and motionless as in us. In the aquatic mammalia, in order to prevent the entrance of water, the meatus is narrow and winding, and the orifice very small; and in quadrupeds which dive or burrow, a double membrane is provided, which can accurately close it. The hippopotamus, which feeds at the bottom of rivers, has an apparatus for the same purpose. (See Dr. Grant, *Lancet*, No. 569., and *Outlines of Comparative Anatomy*. Dr. Roget, *Bridgewater Treatise.*)

Many animals surpass us in acuteness of hearing. The common birds about us hear the faintest sound. " Not only," says Gall, " are the vestibule and semicircular canals proportionally larger in many brutes, but the acoustic nerve and all its apparatus are more perfect. This nerve originates in a more considerable mass of grey substance, and is consequently considerably larger, as any one will find in the sheep, ox, horse, &c. The external concha is much more developed in most brutes, and the great osseous cavities surrounding the labyrinth in many produce a similar effect in augmenting the sound of the solid and elastic vaults. These cavities, which must not be confounded with the mastoid processes, contain, in many brutes, for instance, in the calf, concentric canals which unite into a common cavity, and must evidently increase the sound." (l. c. 4to. vol. i. p. 161.)

CHAP. XXVI.

SIGHT.

"The instruments of vision, — the eyes[a], are two moveable globes, fixed to the optic nerves, whose decussation we formerly noticed, as it were to stalks, in such a manner that their insertion is not exactly opposite the centre of the cornea and iris, but on one side of this imaginary axis, — rather nearer to the nose.

"They consist of various coats containing pellucid humours of different densities, so placed that the rays of light can pass from the transparent anterior segment of the bulb to the opposite part of the fundus.

"The external coat is called *sclerotic.* It is deficient in the centre, and that part is filled up by the *cornea,* which is transparent, lamellated (lined internally by the *membrane of the aqueous humour,* or of Demours), more or less convex, and projects like the segment of a small globe from one of rather larger size.[b]

"The interior of the sclerotic is lined by the *chorioid,* which abounds in blood-vessels[c], especially vorticose veins, and is covered on each side by a black pigment, which adheres but loosely to its concave surface in the form of mucus.[d]

[a] "Sam. Th. Sömmerring (the father), *Icones oculi humani.* Francof. 1801. fol.

Detm. W. Sömmerring (the son), *De oculorum sectione horizontali Commentarius.* Gotting. 1818. fol."

[b] "G. H. Gerson, *De forma corneæ deque singulari visus phænomeno.* Gotting. 1810. 4to.

Al. Clemens, *Tunicæ corneæ et humoris aquei monographia.* Gotting. 1816. 4to.

M. J. Chelius, *Ueber die durchsichtige Hornhaut.* Carlsr. 1818. 8vo."

[c] "Sam. Th. Von Sömmerring, in the *Denkschr. der Akad. der Wiss. zu München.* 1817. tab. 1."

[d] "C. Mundini, in the *Comm. Instit. Bononiens.* t. vii. p. 29.

H. F. Elsaesser (præs. G. C. Ch. Storr), *De pigmento oculi nigro.* Tubing. 1800. 8vo."

"The chorioid is internally coated by the *retina*[e] — an expansion of the optic nerve after this has passed through the sclerotic and chorioid[f], of most beautiful texture[g], and perforated, in the imaginary axis of the eye, between the two principal twigs of the central artery[h], by the singular central foramen of Sömmerring[i], which is surrounded by a yellow edge."[k]

A delicate transparent membrane has been discovered by Dr. Jacob of Dublin between the retina and chorioid, and adherent to both.[l]

"The anterior edge of the chorioid is terminated by a cellular belt, called *orbiculus ciliaris*, by which it adheres firmly to a corresponding groove in the sclerotic, and from which two other membranes of a different kind, viz. the iris and ciliary processes, are expanded in a circular form.

[e] "B. S. Albinus, *Annotat. Academ.* l. iii. p. 59. sq. l. iv. p. 75. sq. l. v. p. 66. sq."

[f] "Walter, *De venis oculi,* &c. Berol. 1778. 4to. tab. i. fig. 2. tab. ii. fig. 2."

[g] "The extremely beautiful blood-vessels of the retina were first discovered by J. Mery to be visible in a living cat plunged under water, *Mém. de l'Acad. des Sc. de Paris, avant* 1699, t. x. p. 650. ; and 1704, p. 265.

The most beautifully radiated surface of the retina in the hare was displayed by Zinn in an admirable engraving. *Comm. Soc. Scient. Gotting.* t. iv. 1754, tab. viii. fig. 3.

By Fontana, in the rabbit, *Sur le vénin de la vipère,* vol. ii. tab. v. fig. 12."

[h] "A plate accurately representing the course of these branches will be found in the *Œuvres de* Mariotte, p. 527. fig. 1."

[i] "Sömmerring, *De Foramine centrali limbo luteo cincto retinæ humanæ :* in the *Comment. Soc. Reg. Scient. Gotting.* t. xiii.

Ph. Michaelis, *Journal der Erfindungen in der Natur-und Arzneywiss,* P. xv."

[k] "As I have discovered this central aperture in the eye of no animal besides man, except the *quadrumana,* the axes of whose eyes are, like the human, parallel to each other, I think its *use* connected with this parallel direction of the eyes, and have endeavoured to explain the connection at large, in my *Handbuch der vergleichenden Anatomie,* p. 402. sq. 2d edit.

As, on the one hand, this direction of the eyes renders one object visible to both at the same time, and therefore more distinctly visible ; so, on the other, this foramen prevents the inconvenience of too intense a light, if there is a probability that it expands and dilates a little under this circumstance, and thus removes the principal focus from the very sensible centre of the retina."

[l] *Phil. Trans.* 1819. Also, on various other points in the anatomy of the eye, *Med. Chirurg. Trans.* vol. xii. P. 2.

"The *iris* (whose posterior surface is lined by a brown pigment, and termed *uvea*) lies anteriorly to the ciliary processes, is flat, and washed on all sides by the aqueous humour; narrower towards the nose, broader towards the temples. Its texture is dense and cellular, and contains no vestige of muscular fibre. We must regard it, with Zinn[m], as a membrane sui generis, and not as a prolongation of the chorioid. The anterior surface is differently coloured in different persons, and, during life, has a flocculent appearance.[n]

"The blood-vessels of the iris run chiefly on its anterior surface, and in the fœtus are continued into the *membrana pupillaris*[o], which begins to open in its centre at the seventh or eighth month of pregnancy,—when the eyes have acquired some degree of size, and when, probably, the elliptic arches of its vessels begin to be gradually retracted into the *inner ring of the iris*, which ring I have never been able to perceive distinctly before that period.

"The posterior of the two circular membranes bears the name of *ligamentum* or *corpus ciliare;* and, inclining backwards, lies at a distance from the iris. Its external edge is thick[p] and adheres to the ciliary circle: the internal is thin, and, together with the adjacent *zonula* of Zinn[q], surrounds the margin of the capsule of the lens. The brown pigment is copiously diffused over it.

"Its anterior surface, lying opposite to the uvea, is striated.

"The posterior, lying upon the vitreous humour, is marked by about seventy plicæ, which are beautifully flocculent, and remarkable for a set of indescribably minute and elegant blood-

[m] "*Comment. Soc. Scient. Gotting.* t. iv. p. 199."

[n] "On the remarkable mutual relation of the arteries and nerves of the internal parts of the eye, and especially of the iris, see Diet. G. Kieser, *De Anamorphosi oculi.* Gotting. 1804. 4to."

[o] "This beautiful membrane was first discovered by Francis Sandys—a celebrated maker of anatomical preparations: it was first described and exhibited in an engraving by Ever. J. Wachendorf, *Commerc. litter. Nor.* 1740, hebd. 18."

[p] "The ciliary canal, discovered by Fel. Fontana, (*Sur le vénin de la vipère,* vol. ii. tab. vii. fig. 8, 9, 10.) and afterwards described more accurately by Adolp. Murray (*Nov. act. Upsaliens.* vol. iii.), runs, in bisulcous animals, along this thick edge."

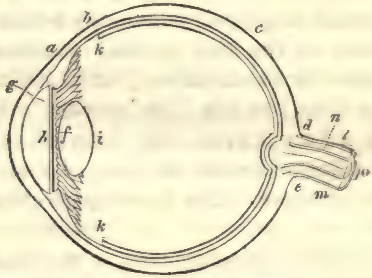
[q] "Doellinger, *Nov. Act. Ac.* N. C. t. ix. p. 267. sqq. tab. vii.
C. J. M. Langenbeck, *Neue Bibl. für die Chirurgie,* iii. B. 1. St. tab. 1. 11."

vessels. These flocculi are named *ciliary processes*, and their use is still an object of inquiry.[r]

" In the bulb of the eye, whose coats we have now described, are contained the *humours*, of three principal kinds.

" The posterior, and by far the greater, part of the globe is filled by the *vitreous* humour, which is in larger quantity proportionally in the human subject, especially after puberty, than in other animals, and so dispersed in innumerable drops throughout the cells of the delicate *hyaloid membrane* that this membranaceo-lymphatic body has the singular appearance of a tremulous jelly.

" Anteriorly it adheres to, and the *zonula* just mentioned surrounds, the capsule containing the *crystalline lens,* immediately around which lies the water of Morgagni."



a, point of junction of the sclerotic and cornea.
b, c, d, the sclerotic; growing thicker and thicker posteriorly.
e, opening of the sclerotic through which the optic nerve runs.
f, anterior surface of the crystalline lens, bounding the anterior chamber of the eye.
g, iris.
h, anterior chamber of the eye.
i, posterior surface of the crystalline.
k k, anterior termination of the retina.
l, m, fibrous covering of the optic nerve, continuous with the sclerotic.
n, proper covering of the optic nerve.
o, section of the optic nerve.

" The lens, itself also very pellucid, is cellular, but so much more dense than the vitreous humour that in the hand it seems

[r] " Consult, among others, Brandis, *Pathologie,* p. 253.
And J. Aug. Hegar, *De Oculi partibus quibusdam.* Gotting. 1818. 8vo. p. 25. sqq."

like a very tenacious, although an amazingly clear, glue. Its nucleus is more dense than the exterior laminæ. The laminæ may be reduced into extremely delicate fibres, converging from the circumference to the centre.[s]

" In an adult man the lens is proportionally to the whole body smaller than in quadruped mammalia; also less convex, especially on its anterior surface.

" The remaining space of the eye is filled by the *aqueous humour*, which is very limpid, and divided by the iris into two *chambers:* — the anterior and larger separating the cornea and iris; and the posterior, in which the uvea lies towards the corpus ciliare, so small as scarcely believed by some to exist.

" These most valuable parts are defended from injury both by the depth of their situation in the orbits and by the valvular coverings of the eye-lids.

" In the duplicature of the *palpebræ*, lie the *sebaceous follicles* of Meibomius[t], thickly distributed: and their edges are fringed by a triple or quadruple series of *cilia*[u]: the cartilaginous *tarsi* serve for their support and expansion, and also facilitate their motion upon the eye-ball.

" Above the eyelids, to use the language of Cicero, are placed the *supercilia*, which preserve the eyes from the sweat flowing from the head and forehead, and in some measure screen them from too strong a light.

" To lubricate the eyes, to preserve their brightness, and to wash away foreign matters, is the office of the *tears;* the chief source of which is a conglomerate gland placed in the upper and exterior part of the orbit. It has numerous but very fine excretory ducts, which are said to discharge about two ounces of tears upon each eye during the twenty-four hours: the tears are afterwards absorbed by the puncta lachrymalia, the function of which may, in a certain sense, be compared to that of the lacteals in the villous coat of the small intestines; from the puncta they are conveyed through the snail's horns, as they are called, into

[s] " Th. Young, *Phil. Trans.* 1795, tab. xx. fig. 2, 3.
Dav. Hosack, ib. 1794, tab. xvii. fig. 4.
J. C. Reil, *De lentis crystallinæ structura fibrosa.* Hal. 1743. 8vo."

[t] " H. Meibomius, *De vasis palpebrarum novis ep.* Helmst. 1666. 4to."

[u] " B. S. Albinus, *Annotat. Academ.* l. iii. tab. iii. fig. 4."

the lachrymal sac, and thence pass into the lower meatus of the nostrils."[x]

The tears appear to me to pass over the ball of the eye as low as the edge of the superior tarsus, which is so applied to the ball as not ordinarily to allow of their ready escape under it.[y] As the upper lid descends and nearly covers the front of the eye during sleep, for the lower has but little motion and the fine inner edges of both meet, the whole of the ball is at this time readily preserved moist. But, when the eyes are open, the front of the eye between the lids would not be moistened unless the upper tarsus occasionally descended with the fluid contained behind it. A portion of the fluid, thus brought down upon the front of the eye, remains after the upper lid rises again after winking, and trickles by its gravity as far as the inferior tarsus, which, ascending a little as often as the superior descends, raises it somewhat. Winking thus preserves the front of the eye constantly moist during the waking state. The under eyelid in rising moves towards the nose, as Sir C. Bell pointed out, and thus directs the tears towards the puncta, and extraneous matters are both pushed and washed towards the inner canthus, where the tears are always seen to run over first.

It may be also observed that, when the tarsi approximate, as they drive before them the moisture of the front of the eye-ball, and the lower at the same time moves it somewhat towards the nose, they quite inundate the puncta lachrymalia, by which circumstance the puncta are, of course, enabled to carry off a large quantity of the secretion, and ordinarily to prevent its overflow, which would occur at the centre of the lower tarsus. During sleep the puncta are not so copiously supplied, as they have only the same share of tears as the eye in general; and there is less occasion for it, because the removal of the stimulus of air and light by the closure of the eyelids lessens the secretion.

[x] "J. Chr. Rosenmüller, *Organor. lachrymalium partiumque externarum oculi humani Descriptio Anatomica.* Lips. 1797. 4to.

[y] The object of this firm application of the tarsi to the eye must be the exclusion of foreign matters from the orbit. Sir C. Bell says that the margins of the eyelids touch at their outer edges only, and leave a gutter between them and the cornea. I cannot conceive this, as the inner edge of the tarsi appears firmly applied to the eye. *Phil. Trans.* 1823.

Dr. Magendie has found the matter of the tarsal or Meibomian glands to be not sebaceous but albuminous, and soluble in the tears: hence we discover why, during sleep, it accumulates on the tarsi, — because its solvent, the tears, are not sufficiently abundant to remove it.

"Thus much it was necessary to premise upon the structure of the organ of vision. We now come to the function of the organ, — to the explanation of vision."

Sir D. Brewster, the best authority upon this subject, gives the following data respecting the dimensions, motions, and refractions of the eye. The total length of the axis of the eye is about 0·91 inch; the principal focal distance of the crystalline lens is 1·73; and the range of the moving eyeball, which determines the field of *distinct* vision, is 110°. The eye being stationary, its field of vision is 120° in the vertical plane, 50° being above the horizontal line and 70° below it. In the horizontal plane its field is 150°, having 60° inwards and 90° outwards.

The refractive powers of the different humours of the eye are as follows; the ray of light being incident upon them from air:—

Aqueous humour.	Crystalline Lens. Surface.	Centre.	Mean.	Vitreous humour.
1·336	1·3767	1·3990	1·3839	1·3394.

The refractive index of the aqueous humour, it will be observed, is almost precisely that of pure water; and the indices of the other media do not greatly differ from it.

As the rays refracted by the aqueous humour pass into the crystalline, and those from the crystalline into the vitreous humour, the indices of refraction of each separating surface of these humours will be

From aqueous humour to outer coat of the crystalline - -	1·0466
From ditto to crystalline, the mean index being used - -	1·0353
From vitreous to crystalline outer coat - - - -	1·0445
From ditto to ditto, the mean index being used - -	1·0332

"Rays of light, falling upon the cornea at an angle more acute

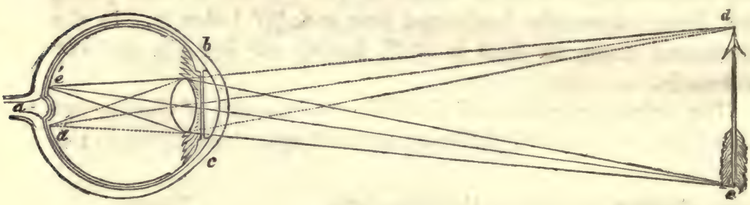
than forty-eight degrees, pass through it, and, from both its density and figure, are considerably refracted towards the axis of the eye, and on entering the aqueous humour they experience rather a less degree of refraction.

" Those rays which penetrate the pupil, and are received by the lens, are still more refracted on account of the greater density of this medium.

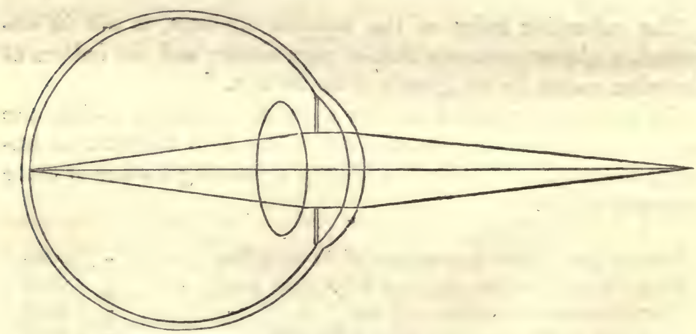
" The less density of the vitreous humour prevents the focus of rays from being too short, and allows it to fall upon the retina and exhibit the image of objects, though, from the laws of light, necessarily inverted."

By means of the indices of refraction above given, and the known dimensions of the eye, it is easy to determine the path which the rays of light travel through the humours of the eye, whether they fall upon it in a parallel or a diverging condition.

Let *a b c* be the eye, and *d e* an object at a considerable



This figure shows how the images of external objects are formed on the retina.



This figure shows how the rays of light issuing from a point fall divergingly on the cornea, and are afterwards refracted so as to meet again in a single point on the retina.

distance from it. The rays which diverge from d and e will, after undergoing the various refractions, converge to the points d' e' upon the retina, and will there form an inverted image of it, precisely in the same manner as a convex lens forms an image upon a sheet of white paper placed at its focus.

That an image or picture is actually thus formed on the retina, may be shown by scraping away the sclerotic coat of the eye of an ox, until it is sufficiently transparent for the image to be seen through it.

"Although the whole of the retina is sensible, it is not throughout equally calculated to receive the images of objects.

"In the first place, the true axis of the human [z] eye, where the optic nerve enters, is proved, by the well-known experiment of Mariotte [a], to be nearly insensible to light.

"The *principal focus* of the rest of the retina, and which must be considered as the chief instrument of distinct vision, falls upon an imaginary axis of the globe, corresponding with the centre of the cornea and of the whole eye. This, however, as Kaestner observes in opposition to Boerhaave, is not to be understood as if only one point of an object could be seen distinctly at once, the eye being fixed, and that, to behold another point, the axis of the eye must be changed; for the sensation of an entire object is simple and complete. [b]

"The habit of directing the axes of the eyes rapidly towards objects is acquired by practice. This is proved by the example of persons who were born blind but recovered their sight after puberty [c]; and of children, who seldom acquire this facility of motion before the third month.

"An object can never be seen unless the angle of vision exceeds 34 *seconds*. This was proved by the very beautiful experiments of the acute Tob. Mayer, who formerly was one of our number: and he demonstrated the great perfection of the human

[z] "I say the human eye; for in some animals now before me, the seal and porcupine, for instance, the true and imaginary axes are the same, the optic nerve lying exactly opposite the centre of the cornea and pupil."

[a] "Troxler speaks of this at large, l. c. t. ii. P. ii. p. 1."

[b] "*In Optica Quædam* Boerhaavii et Halleri *Commentatur* Abr. Gotth. Kaestner. Lips. 1785. 8vo. p. 7."

[c] "See Giov. Bortolazzi, *Sopra una cieca nata guarita.* Verona, 1781. 8vo. p. 99. sq."

sight, by showing that this still remained the limit of vision in any light, — in the splendour of the meridian sun and the faint light of a lantern; so that vision remains almost equally distinct, although the light be considerably diminished.[d]

" We may hence infer the extreme minuteness of the images of objects projected upon the retina[e], and nevertheless impressed so forcibly upon it, that, under certain circumstances, their vestiges remain after the removal of the objects from before the eye.[f]

It has frequently been a question among philosophers, why objects are seen erect, when the images which suggest them to the mind are thus inverted. Some have supposed that infants at first see objects upside down, and afterwards learn to correct their erroneous sensation by comparing the information acquired by touch with that obtained by sight. This opinion, held by Locke, Lecat, Diderot, Buffon, &c., as well as that of our originally seeing objects double and all as at the same distance and correcting these errors by experience and the sense of touch, was amply refuted by Bishop Berkley, and subsequently by Gall[g] and others. The law of visible direction affords the true explanation. The simple statement of this law is that each point of an object is seen in a line perpendicular to the point of the retina on which its image falls. The surface of the retina being concave and nearly as possible spherical, these lines of visible direction meet and cross at a point within the eye which is called the centre of visible direction: the lines from the upper part of the image go to the lower part of the object, and those from the lower part of the image proceed to the upper part of the object. An inverted image thus necessarily produces an erect object, and the external object is the

[d] " Tob. Mayer, *Experimenta circa visus aciem*, in the *Commentar. Soc. Scient. Gotting.* t. iv."

[e] " De la Hire, *Accidens de la Vue*, p. 375."

[f] " Gassendi, *Vita* Peireskii, p. 175. sq. Hague, 1655. 4to.

Franklin, *Letters on Philosophical Subjects*, at the end of his *Expts. on Electricity*. Lond. 1769. 4to. p. 469. sq.

Rob. War. Darwin, *Experimenta nova de spectris s. imaginibus ocularibus, quæ objectis lucidioribus antea visis, in oculo clauso vel averso percipiuntur*. Lugd. Bat. 1785. 4to.

Dr. Darwin, *Zoonomia*, t. i.

C. Himly, *Biblioth. Ophthalmolog.* t. i. P. ii. p. 1."

[g] l. c. 4to. p. 180. sqq.

thing to which the mind attends, and not the picture on the retina. The mind is not placed behind the eye to look at this image, as an observer is placed behind a camera obscura: neither does it in this case, more than in any other concerning perception, attend to the sensations themselves, which serve solely to suggest to it the causes which produce them.

" Since many conditions are requisite for distinct vision, the Creator has wonderfully ordered the functions of these organs.

" A sufficient, but, at the same time, a definite, quantity of light, not too intense for distinct vision, is provided in two modes: — First, according to the greater or less intensity of the rays, a greater or less number of them pass to the lens; — Secondly, that portion which is superabundant and injurious to vision is absorbed.

" The first point is effected by the motion of the iris; the second, by the pigmentum nigrum.

" The iris is endowed with remarkable mobility, and thus accommodates itself to the intensity and distance of light, so that, when exposed to a strong light or to near objects, it may expand itself and contract the pupil, but, when to a weaker light or more remote objects, it may contract itself and dilate that opening.[h]

" Physiologists have given different explanations of this motion. Some ascribe it to the varied impulses of blood into the vessels; others to contraction of the imaginary muscular fibres of the iris. I have shown, in a particular treatise, that both these circumstances are impossible, and that its proximate cause may be sought for with more probability and reason in the vita propria of the iris; the more remote cause, as we formerly hinted, can be solely the reaction of the sensorium.[i]

" The function of the dark pigment, so frequently mentioned, viz. to absorb the superfluous rays, and, consequently, its importance to the perfection of vision, are demonstrated, among other modes, by the dissection of different kinds of animals, and by the diseased condition of Albinos, whose eyes are very

[h] " Zinn, *De Motu Uveæ*, 1757, in the *Comment. Soc. Scient. Gotting.* t. i. Fel. Fontana, *Dei Moti dell' Iride.* Lucca. 1765. 8vo."

[i] " For other explanations consult Troxler in Himly's *Ophthalmol. Biblioth.* t. i. P. ii. p. 21."

tender and impatient of light from the absence of this pigment."[k]

Adaptation of the eye.— When the eye is directed to objects at a distance, it is unable, at the same time, to see distinctly objects which are near. Some change is therefore requisite to accommodate the eye to see perfectly at different distances. That the eye thus adapts itself to distinct vision by a voluntary act, is evident from the following simple experiment. If you hold a pencil near the eye and direct the attention steadfastly to it, distant objects will appear confused; but if, without changing the position of the eye, the attention be transferred to these distant objects, they will become distinct and the pencil will appear confused. Many hypotheses have been proposed to explain the actions by which this adaptation of the eye is effected, but none yet advanced has been deemed entirely satisfactory. Kepler supposed that the eye elongates itself in the direction of its axis in proportion as the object to be viewed is nearer. Dr. Jurin, Sir E. Home, Ramsden, and others, regarded the cornea as capable of changing its form and curvature,— becoming more convex when the eye is adjusted to see nearer objects. Descartes, Pemberton, Albinus, Hunter, Olbers, and Dr. Young have endeavoured to prove that the crystalline lens is capable of moving in the direction of the axis of the eye so as to vary its distance from the retina, — that it advances to see near objects, and recedes to become fit for seeing distant objects. La Hire and Le Roy supposed that the mobility of the pupil is alone sufficient to account for the phenomena. Dr. Magendie hastily denies that any adaptation is necessary, " because," says he, " the picture seen at the back of the eye of an ox, when the sclerotic is scraped away, is equally distinct at whatever distance the object is placed before it."

On paying attention to the phenomena, it will be observed that the effort of adapting the eye to a near object is invariably attended by the contraction of the pupil. Several eminent writers have hence considered the motion which causes the adaptation to be a consequence of the mobility of the iris. Dr. Knox thinks that the contraction of the iris alters the curvature of the crystalline lens; Sir D. Brewster, that it displaces the crystalline;

[k] " I have spoken of Albinos at large in my work, *De Generis Humani Varietate Nativa*, ed. 3. p. 274.; and in my dissertation, *De Oculis Leucœthiopum*."

and Prof. Mile of Warsaw, that it changes the curvature of the cornea.

Prof. Mile, by a great number of accurate and satisfactory experiments, for which I refer the reader to the original memoir[1], has arrived at the following conclusions. Their truth is independent of his hypothesis of the dependence of the curvature of the cornea on the contraction of the iris, and the opinion of Sir D. Brewster or Dr. Knox might be substituted for it with equal propriety.

The eye does not see with equal distinctness objects at all distances, but only when they are within a certain distance. This does not depend on external causes, such as the diminution of the optic angle, and the obscuration of the object by the intermediate air; for, to see clearly and to see distinctly are not identical. The causes of distinct vision are internal, and situated in the eye itself. They are two in number: one disposes the eye for the continuous distinct vision, and the other for the transient distinct vision of objects at different distances; but neither of them can act except within certain limits. These limits are greater for the presbyope, or shortsighted, than for the myope, or longsighted, person. These adaptations both depend on the action of the iris, which can at the same time act in two ways to produce two effects: first, by the contraction of its aperture, and, secondly, by the flexion of the cornea; the alteration of the size of the pupil only, however, is visible. The adaptation of the eye for the continuous distinct vision of objects contained within certain limits is owing to the diffraction of the rays of light near the edge of the aperture of the iris, in consequence of which there are formed, by a single external luminous point, several foci instead of one successively ranged in a line of a certain length; so that the object may change its distance within certain limits, and yet one of its foci shall always fall on the bottom of the eye. This focal length is inversely as the magnitude of the pupil. The borders of indistinct objects appear radiated, and to the phenomenon of confusion is added the motion and multiplication of the

[1] *De la cause qui dispose l'œil pour voir distinctement les objéts placés à différentes distances:* par Jean Mile (traduit du Polonais). Magendie, *Journal de Physiologie*, t. vi. p. 166.

image when the edges of bodies are brought near the side of the fasciculus of rays which enter the eye: prismatic colours also appear. All these phenomena, which are observed in an eye performing its functions, may be produced by an apparatus, the structure of which resembles that of the eye; and even by a common lens, if we substitute for the motion of the pupil diaphragms of different sizes. The nature of all these phenomena proves that diffraction is their common origin, and they may be considered as constituting a separate kind of optical illusions resulting from diffraction. The second cause which adapts the eye for the momentaneous distinct vision of objects depends neither on the action of the external muscles of the eye, the advancement of the bottom of the eye, nor on any alteration of the form or position of the crystalline lens; but appears to be owing rather to the change of the curvature of the cornea by the contraction of the iris, which occurs only when the eye adapts itself to see very near objects, as is proved by the simultaneous approximation of the pupil.

Besides the motions of the pupil which accompany the adaptation of the eye to different distances, it also varies with the intensity of the light to which the eye is exposed, contracting in a strong light, and dilating in a faint light. This effect is particularly observable in persons whose pupils are large. The sympathetic action of the pupils of both eyes is worthy of remark: while the same light is regarded, the pupil of one eye will dilate immediately the other eye is covered, and again contract when the hand is removed and both organs are equally exposed to the light.

Correction of spherical aberration in the eye. — In ordinary lenses the rays which pass through them at different distances from the centre are not refracted to the same point or focus, and the images they form are consequently indistinct. This defect, which is called spherical aberration, is, according to Sir D. Brewster, remedied in the eye by means of the variable density of the crystalline lens. The refractive power of this body being greatest at its centre, and decreasing towards its circumference, the central and extreme rays are both refracted to the same point. According to the experiments of M. Chossat, the ellipsoidal figure of the cornea is sufficient to effect this correction.

Chromatic aberration. — In consequence of each differently

coloured ray possessing a different index of refraction in the same medium, a lens refracts these variously coloured rays to different points or foci. This effect, which is called chromatic aberration, is another cause of indistinctness in images formed by lenses, for from this cause they appear surrounded with coloured fringes. When the eye, however, is adjusted to the proper focal distance, an object appears perfectly colourless. It is evident, therefore, that either the eye, when thus adjusted, is by some contrivance rendered achromatic, or that the aberration is so small as to be insensible. Sir D. Brewster is of the latter opinion, which was also held by Dr. Maskelyne. Of those who maintain that there exists a correction for chromatic aberration, Euler, Coddington, and Professor Powell assert that a compensation takes place between the refractions of the different media of the eye, each giving a different explanation; while D'Alembert supposes that the agitation, occasioned at any one point of the retina, extends itself into the adjacent points, and, each point being thus influenced by the sum of the effects due to all the coloured rays at once, perfect vision is the result. When the rays do not converge accurately on the retina, the dispersion is sensible; and, from this cause, objects, seen either within or beyond the proper focal distance, are seen with coloured borders.

Single vision with two eyes. — When we look at an object, an image is formed on the retina of each eye, and yet we see only a single object. Two different opinions have been maintained respecting the cause of this singleness of vision with both eyes. Several distinguished philosophers, and among others Dr. Reid, suppose that there is a physiological connection between certain points of the two retinæ, and that objects are only perceived as single when their images fall on corresponding parts of the retinæ: the decussation of the optic nerve is brought as an argument in support of this opinion. Others, including Dr. Smith and Sir D. Brewster, do not admit this supposed necessary connection between corresponding points of the expansion of the optic nerve, but assert that objects are seen single merely because they are seen by both eyes in the same place; single vision is, according to this opinion, a necessary consequence of the law of visible direction.

Insensible spot of the retina. — The retina, from its being an expansion of the optic nerve, has generally been regarded as the

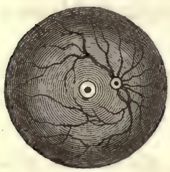
seat of vision. But Mariotte, having found that images which fall on that part of the retina where the optic nerve enters it are invisible, concluded, because where there is no chorioid there is no vision, that the chorioid performs the functions attributed by most physiologists to the retina.

Mariotte performed his well-known experiment in the following manner:—He made two spots in the same horizontal line upon the wall of a room, and, having closed the left eye, placed the right eye opposite the left spot, and gradually moved backwards until the right hand spot disappeared,— a circumstance which occurs when the image falls on the place where the optic nerve enters the retina. The experiment succeeds very well when two wafers are placed on the wall about three inches apart, and the observer commences to recede when at the distance of twelve inches from them. A very ready mode of trying this experiment is the following:—Place two coloured wafers upon a sheet of white paper, close one eye and fix the other opposite one of the wafers, then move the outside wafer, always in the same straight line, until it is invisible; when in this situation, if the wafer be moved to the right, to the left, above, or beneath, it is again seen.

Purkinje has remarked that the spot of the retina is not insensible to the stimulus of light, as it is generally stated to be; for, if a candle be substituted for the moving wafer of the preceding experiment, though the flame is not seen, a red glare is perceived. It can scarcely be doubted that the insensible point is the place occupied by the central artery of the retina, and the chief argument for the chorioid being the seat of vision therefore falls to the ground.

We are indebted to Purkinje for a most beautiful experiment, by which a person may see the blood-vessels of his own retina. The experiment succeeds best in a dark room, when one eye is shaded from the light, and the flame of a candle is placed by the side of the unshaded eye, but so as not to occupy any of the central part of the field of view. So long as the flame of the candle remains stationary, nothing further occurs than a diminution of the sensibility of the retina to light: but, after the flame has been moved upwards and downwards, through a small space, for a length of time, varying with the susceptibility of the person on whom the experiment is tried, the phenomenon presents itself. The blood-vessels of the retina, exactly as represented in the

engravings of Sömmerring, are distinctly seen greatly magnified and projected apparently on a plane before the eye. The image continues only so long as the flame is in motion: when the flame becomes stationary, it immediately dissolves into fragments and soon after disappears. Prof. Wheatstone finds that the susceptibility of seeing it depends upon the size of the pupil: the image readily appears to those whose pupils are large, while, on the contrary, the experiment rarely succeeds with a person whose pupil is small. I can see the blood-vessels of my own retina and the blood circulating through them, just as in a frog's web under the microscope, by merely closing my eyes and excluding the light by placing my hand before them. The phenomenon occurs in this way more readily at one time than at another: and some persons say they never perceive it.



A view of the retina, with the ramification of its central artery. In the centre is seen its central hole, surrounded by a circle. To one side of this is the bulb of the optic nerve.

Purkinje has attempted no explanation of this phenomenon, but contented himself with simply stating the fact. Prof. Wheatstone considers that it is a shadow, resulting from the obstruction of light by the blood-vessels spread over the retina. The difficulty, he observes, is not to account for the appearance of the image, but to explain why this shadow is not always visible. He adduces a number of facts observed by Pictet, Sir D. Brewster, and others, which tend to prove that an object, either more or less luminous than the ground on which it is placed, becomes invisible when continuously presented to the same point of the retina, the rapidity of its disappearance being greater as the difference of luminous intensity between the object and the ground is less: but, by continually shifting the place of the object on the retina, or by making it act intermittingly on the same point, the object may be rendered permanently visible. To apply this explanation to Purkinje's experiment, Prof. Wheatstone observes that, whenever the flame of the candle changes its place, the shadows of the vessels fall on different parts of the retina; as is evident from

the motion of the figure, which, while the eye remains at rest, is always in a contrary direction to that of the flame. Hence the shadow, being thus made to change its place on the retina, remains, according to the law above stated, permanently visible; but, instantly the flame is at rest, the shadow also becomes stationary and consequently disappears.

Sir D. Brewster offers a different explanation. He considers that the light is propagated from the luminous image of the candle to other parts of the retina, and that, though the retina, in contact with the blood-vessels, is sensible to direct light, it is insensible to propagated light, and therefore the blood-vessels are delineated in obscure lines. This explanation does not agree with the fact that the vessels continue to be seen only while the flame is in motion.

Prof. Wheatstone has described several original and instructive variations of the experiment, for which we must refer to his own account.[m]

Duration of luminous impressions on the retina. — The effect of light upon the eye continues for some time after the light itself has ceased to act. If a red-hot coal be rapidly whirled round so as to return to the precise point from which it started, it will produce a perfect ring of light, although the coal can be at one point only of the circle at the same instant. Chevalier D'Arcy was the first who made this experiment the subject of philosophical consideration: he ascertained that the impression on the retina remained about the eighth of a second. Prof. Wheatstone has devised a very instructive experiment to illustrate this property of vision. A narrow slit is made in a disc from the centre to the circumference: when this disc is stationary and held before a window blind or a strongly illuminated picture, a very limited portion only of the object is seen through the linear aperture; but, on causing it to revolve rapidly on its centre, the different portions of the picture, which are seen through the disc in its successive positions, remaining on the eye, the entire object is visible at the same time and the solid disc appears perfectly transparent.

The stationary appearances of moving wheels as observed by Drs. Roget and Faraday, Dr. Paris's thaumatrope, Professor

[m] *Contributions to the Physiology of Vision. Journal of the Royal Institution*, Nos. 1. and 3.

Plateau's well known optical illusion — the phantascope, Prof. Wheatstone's kaleidophone, and the revolving mirror by which he has measured the velocity of electricity and the duration of the electric spark, are all applications of this physiological law.

Ocular spectra. —When the eye has been fatigued by looking at any particular kind of coloured light, and is afterwards directed to a white surface, the surface will not appear white, but of a different colour, which is called the accidental colour of the colour which was first regarded by the eye. This fact may be proved by placing a *red* wafer on a sheet of white paper, and fixing the eye for some time steadily to a dot at its centre: when the eye is turned aside to an uncovered part of the paper, a circular spot of the same size as the wafer will be seen, but its colour will be *green.* This image changes its position as the eye moves, and is called an ocular spectrum.

To determine the accidental colour of any colour originally presented to the eye, the following remarks must be attended to. There are three primary and distinct colours, red, yellow, and blue; and all the compound colours that exist in nature are different combinations of these. Orange is a compound of red and yellow; green, of yellow and blue; purple, of blue and red; and white is a neutral combination of the three primary colours. An accidental colour is always found to be that which, added to the original colour, produces white; and these two colours are hence said to be complementary.

The theories which have been advanced to account for the phenomena of ocular spectra may be reduced to two.

The most usual theory in its most general form supposes that, when any simple or compound colour is continuously presented to the eye, the part of the retina where the image falls becomes less sensible to impressions of the same kind, but retains its susceptibility for other kinds of impressions: if, therefore, while the retina is in this state, the eye is transferred to a white surface, the spectrum will appear as if the colour originally seen were subtracted from the white. This explanation agrees with a great many observed facts, but there is one which seems in direct contradiction to it. A complementary spectrum is seen when the eye is shut, and when, consequently, there is no white light to furnish the complementary colour. This phenomenon has given rise to another explanation as to the origin of ocular spectra,

which assumes that any colour presented to the retina stimulates it and excites it to a reverse action which produces the complementary colour. Professor Plateau has supported this theory with much ingenuity, but there are numerous facts which do not accord with it.

Longsightedness and shortsightedness. — That case of defective vision which is called longsightedness arises from the crystalline lens being too flat; the rays proceeding from near objects, instead of converging to distinct foci on the retina, converge behind it, and therefore form no distinct image. This defect, which is an ordinary effect of old age, may be remedied by the use of a convex lens, which enables the eye to converge the rays so as to form a perfect image on the retina.[n]

Shortsighted persons are unable to see at a distance, and are obliged to bring small objects very near the eye to see them distinctly. This defect, which often occurs in young persons, arises from the eye being too convex, from which cause the rays of distant objects converge to foci before they fall on the retina. The imperfection may be remedied by using a concave lens, which renders the rays less converging and enables them to form a distinct picture at the bottom of the eye. There are other cases of defective vision arising from the malformation of the organ, but these are of the most common occurrence.

[n] In hemiplegia, a sense sometimes becomes morbidly acute. Dr. Heberden (*Comment.* p. 292.) mentions a hemiplegic person whose smell became greatly heightened. Frequently we find such patients sensible to the crawling of the minutest insect on the arm. I lately attended a gentleman about forty years of age, who had suddenly been attacked with hemiplegia, and in bed he heard the least sound at the bottom of the house with an acuteness which surprised him, and could tell the hour by a watch placed on a table at such a distance from his bed as to have rendered it impossible for him to distinguish the hands when he was in health. Dr. Brachet relates that, when he was *interne* at the Bicêtre in 1811, the *infirmier* of the surgical ward one day astonished him by the extent which his vision had acquired since the day before. The man could distinguish the most minute objects at an enormous distance. Five hours afterwards he felt a slight headach, and in a few hours more was seized with a thundering apoplexy (*une apoplexie foudroyante*), and died the next night. A fresh coagulum was found in the right optic thalamus. The inflammation which had preceded this effusion had irritated by its proximity a part of the brain concerned in vision. These were instances of longsightedness; but not of mere longsightedness, but general acuteness of sight, as the persons saw well not only at great distances, but at small distances likewise.

Optic nerves. — Such facts have been thought a reason for believing the decussation of the optic nerves partial, and some say that the outer portion of the tractus optici goes to the outer part of the corresponding nerves, and the inner to the inner portion of the opposite. But Dr. Magendie divided from before backwards the junction of the optic nerves, and found blindness induced.[o]

The decussation of the optic nerves is shown by blindness of one eye being induced if the nerve on the same side is divided anteriorly to the union, and of the opposite eye if the division is made posteriorly to the union: or by destruction of an eye causing the nerve of the same side to waste as far as the union, and of the opposite side beyond the union.[p] Yet cases are on record where the wasting of the nerve in loss of sight continued throughout on the same side, but such are probably suspicious.

The thalami optici are improperly named, as they do not give origin to the optic nerves. These may be traced to the anterior corpora quadrigemina, pressure or disease of which produces blindness, and which waste if the nerves waste.[q] Sömmerring first noticed this in blind horses. Gall confirmed his observations. Dr. Vimont states that, on examining fourteen old blind horses, he found the anterior quadrigeminum opposite the blind eye lessened in all, and completely atrophied in two. He then cruelly took out the left eye of four rabbits, the right of four others, and both eyes of another. At the expiration of ten months he killed them all, and found the right anterior quadrigeminum much smaller than the left in the first four, the reverse in the second four; and both the anterior and posterior much smaller in the rabbit deprived of both eyes than the healthy tubercles of the other eight. The optic nerve of all the blind eyes had lost $\frac{1}{3}$ of its volume, and looked like the horn of a lantern. Dr. Magendie informed Dr. Vimont that the atrophy of the tubercle occurs much more quickly in birds, and Dr. Vimont found this to be the fact.[r]

Drs. Carus and Tiedemann make Gall consider the posterior quadrigemina as the roots of the olfactory pair, whereas he has

[o] *Précis de Physiologie,* t. i. p. 71.

[p] Dr. Magendie, l. c. ibid.

[q] On the optic nerve consult Gall, l. c. 4to. t. i. p. 113. sqq.

[r] l. c. t. i. p. 296. sq.

declared the opposite opinion on account of the existence of the posterior quadrigemina in animals apparently destitute of olfactory nerves. He believed that the posterior reinforced and protected the optic nerve as well as the anterior, but in a different manner, since in different animals they are in different proportions, and the posterior scarcely perceptible, if not absent, in some whose vision is perfect. Nay, he believed that the greater part of the corpora quadrigemina have other offices relating to the spinal chord below and to other cerebral parts than those concerned in vision above. If the surface either of their anterior part, of the bulb of the olfactory nerve, of the grey band on the sides of the fourth ventricle, or of the ganglion of the acoustic nerve, is touched, no contraction ensues; but injure them to a certain depth, and convulsions take place.[s] The optic nerve is certainly not derived, he says, from the tubercles only; the internal and external corpora geniculata, &c. give it many filaments.

Many recorded cases, as well as many in my own practice, prove that one half of the retina may be paralysed, while the other half remains unaffected; and this effect may be common to both eyes, or peculiar to one. Dr. Wollaston[t] relates that it twice occurred to him not to be able to see but on one side of the axis of vision. The first time, the left side of each eye was affected; he saw but the half of a man's face or of any object he looked at; and, in attempting to read the name JOHNSON over a door, he saw only . . . . SON, the commencement of the name being totally obliterated from his view: the complaint was of short duration. About nineteen years afterwards the phenomenon recurred: this time, the right side of the eye, about three degrees from the centre of the retina, was affected, and its duration was ten minutes. Two analogous cases are also mentioned by Dr. Wollaston. Desmoulins[u] states that M. Arago has experienced this affection of vision three times: the first two times, objects situated to the right of the axis of vision were invisible; the third time he saw objects on the right only of this axis. The same author notices also the following remarkable case. In consequence of a cerebral fever, the external side of the left retina of M. de M—— became insensible: with this eye he

[s] l. c. 8vo. vi. p. 253. [t] *Phil. Trans.* 1824.

[u] *Anatomie des systèmes nerveux des animaux à vertèbres*, t. ii. p. 673.

saw objects only situate to the left of the centre of vision, and, as at the same time there was an outward deviation of the axis of this eye, through a paralysis of the nerve of the third pair, when he employed both eyes, he saw objects double; but, what was still more singular, the right eye being closed, he saw with the left eye the objects removed from twenty to twenty-five degrees to the right of their real position.

If the fifth pair, which gives sensibility to the face, is divided, the eye, nose, and tongue, lose their sense of touch, — ordinary sensibility,—in common with the skin, and are not excited by mechanical or acrid stimulus as before.[x] In this experiment, the pupil becomes greatly contracted in rabbits and guinea-pigs, and dilated in cats and dogs.[y] The retina has very little ordinary sensibility, as Dr. Magendie showed by pricking and tearing it with little or no pain; whence contraction of the pupil does not follow the application of any stimulus excepting light. The third pair, which is a nerve of motion, supplies, in common with the fifth pair, the iris, and therefore Mr. Mayo found that division of it, at least in cats and pigeons, causes dilatation of the pupil, like division of the optic nerve; the dilatation arising in the former case from the cerebral influence being no longer conveyed, and in the latter from the cerebral influence being no longer excited. On stimulating the ocular end of the third pair, divided in pigeons, after removing the brain, he says that the iris suddenly acts: and, on stimulating not the ocular, but the cerebral, end of a divided optic nerve, the same thing happens. M. Fleurens says that irritation of the superior quadrigemina causes contraction of the iris, and extirpation of them its dilatation.

Judgment of colour.—Persons, all having excellent eyes, and seeing perfectly well, differ much in their powers of recognising persons, finding their way, &c. In none of these points is the difference so striking as with respect to judging of colours. It is by no means uncommon to meet with individuals whose eyes appear excellent, and whose sight is excellent, and who may judge of form and distance correctly, but who cannot distinguish certain colours. Dr. Nicholl describes a boy who confounded green with red, and called

[x] Dr. Magendie, l. c.

[y] Dr. Magendie, l. c. Mr. Mayo informs us that, after death, in the cat and pigeon the pupil is always dilated, and in the rabbit contracted. *Outlines, &c.*

light red and pink, blue. His maternal grandfather, and one uncle, had the same imperfection. This uncle was in the navy, and, having a blue uniform coat and waistcoat, purchased a pair of red breeches *to match*.[z] Dr. Nicholl mentions a gentleman who could not distinguish green from red. The grass in full verdure always appeared to him what others call red; and ripe fruit on trees he could not distinguish from the leaves; a cucumber and a boiled lobster were of the same colour in his sight; and a leek resembled a stick of sealing-wax. This person had a brother and a niece — the daughter of another brother, in a similar predicament.[a] Indeed, the defect has frequently occurred in several members of the same family, and frequently has been hereditary, sometimes passing over a generation, like other peculiarities of structure. It is observed more frequently, perhaps, in men. In the rarest and most extreme cases no colour is distinguished, all objects appearing in this respect alike. In all the cases in which the point has been examined, the part of the cranium under which,

[z] *Med. Chir. Trans.* vol. vii.

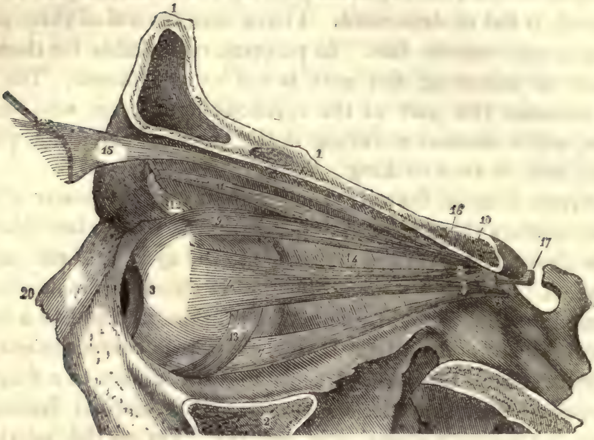
[a] l. c. vol. ix. A case communicated to Dr. Priestley will be found in the *Phil. Trans.* 1777. The man had two brothers with the same defect. Another will be found in the vol. of 1778. The gentleman's father, maternal uncle, one of his sisters, and two of her sons, had the same defect. In the *Phrenol. Trans.* is another by Dr. Butter. In the *Manchester Memoirs*, vol. v., are others. One such person painted a man's head with a *green* beard and *blue* cheeks. In Mr. G. Combe's *System of Phrenology*, and the *Edinburgh Phrenological Transactions*, are mentioned one of three brothers and a cousin, who inherited it from their maternal grandfather, the intervening generation not having it. Professor Dugald Stewart, and Mr. Troughton, as well as many of his family, could not distinguish colours; and the celebrated instrument-maker was therefore prevented from applying himself to execute any thing in which it was necessary to distinguish them. Dr. Dalton has the same defect. A case of this defect is recorded in the *Edin. Phren. Trans.* by Dr. Butter of Plymouth; and, to show what irrational hostility is offered to phrenology by men of whom we might expect better things, I must mention that the paper was sent to the *Edinburgh Philosophical Journal*, but that the editor, Sir David Brewster, choosing that it should not support phrenology, altered the title, without consulting the author, to *Remarks on the Insensibility of the Eye to certain Colours*, and suppressed the phrenological comments, "for obvious reasons," he says, viz. that phrenology is not a substantial science." Yet Sir David Brewster would wish to be considered a philosopher in all his intellectual and moral doings. Still more lamentable and very recent conduct with the view of suppressing phrenological truth may be seen, in the case of *The Edin. Med. and Surgical Journal.* See *The Edinburgh Phrenological Journal*, December, 1836; and June, 1837, p. 632.

according to Gall, the organ for judging of the harmony of colours is placed, is flat or depressed. I have seen several of these cases, and in all this was the fact. In painters, remarkable for their excellence of colouring, this part is full or prominent. The contrast between this part of the forehead in a person who has the defect, and in another excelling in the power of colouring, placed side by side, is very striking.

Professor Dugald Stewart remarks that, "in the power of conceiving colours there are striking differences among individuals;" and he does not ascribe the difference to the eyes. "I am inclined to suspect," he says, "that in the greater number of instances the supposed defects of sight ought to be rather ascribed to a defect in the power of conception."[b] Mr. Stewart is correct in exempting the eye from blame, and ascribing the defect to a defect in conception; but, since he has no idea of a distinct faculty for colours, he means conception in general. Yet, as the individuals are not deficient in other conceptions, some reason must be given for the deficiency of conception in this one point. He thinks it arises "probably in consequence of some early habit of inattention." Now this is sad trifling in a philosopher. What particular attention do children, who distinguish colours accurately, bestow? They distinguish without effort; and those who cannot, are not only not proved to have been inattentive, but have, most probably, been often extraordinarily attentive, in the hope of seeing what others can see. How should want of attention to this one point run in families and be hereditary, passing through a generation, &c.? This is a specimen of the errors of metaphysicians. They see, and generally acknowledge, that the brain is the organ of the mind; yet they observe the faculties of the mind without even once considering the organ which possesses, or is employed in the working of, these faculties. Gall examined the two together, and we now know through him that local deficiency of brain both exists where the power of distinguishing colours is deficient, and is hereditary with this deficiency.

Motion of the eyes. — The eye is moved by six voluntary muscles, — four straight, a superior, inferior, external, and internal; and two oblique, a superior, with its tendon running round a pulley, and an inferior.

[b] *Elements of the Philosophy of the Human Mind*, ch. iii.



Left eye, seen outside, the outer part of the orbit having been removed.

1, 1. Portion of the upper part of the orbit belonging to the frontal bone.
2. Section passing through the malar bone and the malar process of the superior maxillary.
3. Globe.
4. External rectus muscle.
5. One of its two posterior insertions, running to the small wing of the sphenoid.
6. The other of these insertions, running inwards to the cavernous grove.
7. Inferior rectus.
8. Its posterior insertion.
9. Superior rectus.
10. Its posterior insertion in the small wing of the sphenoid.
11. Superior oblique.
12. Its reflected tendon.
13. Inferior oblique.
14. Internal rectus.
15. Levator palpebræ superioris.
16. Its posterior insertion.
17. Optic nerve.
18. Part of the sphenoid.

The motions of the eyes which result from the actions of these muscles were investigated, and the mental perceptions attending them analysed, with considerable success, by Dr. Wells. Sir Charles Bell long afterwards took up the subject, and published some opinions which appear to me altogether groundless. [c] He fancies that the pair of pathetic or internal motor nerves belong to

[c] *Phil. Trans.* 1823.

his respiratory set and are for expression, and that the two oblique muscles have the same destination, and are not voluntary; while the four recti muscles and their common motor and abducent pairs of nerves are voluntary. Now, in the first place, all the objections that I formerly made to his views of a respiratory set of nerves for expression (p. 459. sqq. *suprà*) hold good in the present case, which is merely a particular instance of those views. The absurdity of applying the term respiratory to nerves and muscles of the eye is too manifest to require comment. In the next place, he conceives that the two oblique muscles are never voluntary; and he contends that the superior draws the pupil downwards and outwards, the inferior upwards and inwards. Other writers [d] say downwards and inwards, and upwards and outwards; but he agrees with all, that their combined action draws the eye towards the nose, though I hardly understand how, on either supposition, such a motion inwards can result. Now, we can move the eyes downwards and outwards, and upwards and inwards, at pleasure: we can also make them approach each other at pleasure, and it is a mere assumption, and a very improbable assumption, that we do this by the internal straight muscles, and not by the combined action of the two obliques. He mentions experiments in which he divided the superior oblique, and another in which he divided the inferior oblique; and he asserts that the voluntary motions were unaffected. The poor animal no doubt moved its eye upwards and downwards, inwards and outwards, as it had four muscles left for these purposes: but we, of course, have no information given us that an attempt was made to induce the animal to approximate both eyes together, as in looking now at a *distant* and now at a *near* object in the same line; and this I believe to be the use of the oblique muscles, just as it is of the straight to act when we look in different *directions*. He divided the superior oblique of the right eye, held open the eyes, waved the hand before them, and found the right eye move upwards and inwards, and the other scarcely so in that direction, and the dog "seemed to have a difficulty in bringing it down again." But this did not show that the muscle was involuntary. If the superior oblique moves the eye downwards and outwards, its division explained, on his own views of the effects of these mnscles, why the animal could not move the eye

[d] *Manuel d'Anatomie comparée*, par Jules Cloquet, p. 139. sq.

simply inwards; and why the inferior pulled it inwards and upwards, being no longer antagonised by the upper; just as the muscles of one half the face draw the features to their side if their antagonists of the other half are paralysed. Not one experiment mentioned by him shows the oblique muscles to be involuntary. He says that when we wink, we draw the eyes up under the upper lid. Now we can wink voluntarily: and, if the eyes do ascend in winking, which I do not believe [e], why should they not ascend by the superior straight muscles? His ideas on the action of the oblique muscles seem all confusion. At one time he says that the superior oblique moves the pupil downwards and outwards, the inferior upwards and inwards, and that "their combined action draws the eye-ball *towards the nose*" (p. 312.): [f] at another (p. 327. sq.), that the eye rolls *upwards and inwards*, when they are balanced: at another (p. 314.), that, if the superior is prevented from acting by being divided, the eye equally turns upwards and inwards; and, indeed, (p. 315.) that the inferior gains in power of elevating the eye-ball by the division of its opponent the superior, and that is its own proper action. In many places (pp. 294. sq. 298. 303. 316. 326.) he speaks simply of the eyes turning upwards in winking and sleeping, and refers this to the combined action of the two obliques, neither of which, nor both together, are able, or are supposed by him, to simply elevate the eye. He is farther confused, for, although he contends that the obliques are involuntary muscles and act in winking and for expression in the waking state, he says "that in sleep, faintness, and insensibility, the eye-ball is given up to the one (the oblique), and in watchfulness, and the full exercise of the organ, it is given up to the influence of the other (the straight) class of muscles." (p. 292.)

Again, I presume that, when the cornea moves straight under the

[e] To show that, in winking, the eye turns up as the eyelids close, he mentions a case of inflammation of the cornea through the immobility of the eyes and eyelids. If the eye could have moved, the immobility of the eyelids would not have had this effect: nor would it have resulted if the eyelids only could have moved. But this case is no proof that the eye naturally turns up in winking, and that the motion of the lids alone is not sufficient to preserve the eye moist and prevent inflammation.

[f] I make the references to the paper as printed with others by him in one octavo volume, under the title of *An Exposition of the Natural System of the Nerves of the Human Body*. 1824.

upper or lower eyelid on the sudden approach of any thing to it, the motion is from fear, and as instinctive, and expressive, and *respiratory!* as any motion can be: yet it is accomplished by the superior or inferior straight muscle of the organ, — both voluntary muscles.

Not only do the motions of the straight muscles continually express the passions, but the abducent or external is actually the antagonist of the two obliques when, in Sir C. Bell's own words, "their combined action draws the eye-ball towards the nose;" just as the two obliques when acting separately are the antagonists of each other: and the circumstance of this muscle antagonising not only the internal straight muscle but the combined action of the two obliques may explain why it has a distinct nerve.

He further contends that the eye-ball moves so that the cornea always rises under the upper lid the moment that the eyelids close (p. 294.), and in some places he says it not only rises but moves inwards. (p. 328.) I have raised the upper eyelid of persons whose eyes were shut, and found the cornea sometimes raised under the upper lid, but as often depressed under the lower lid. I have often looked at persons whose eyes were closed, and seen the cornea projecting at the centre of the upper eyelid, in the same line as when the eyes were open. He states that, "if we fix one eye upon an object, and close the other with the finger in such a manner as to feel the convexity of the cornea through the eyelid, when we shut the eye that is open, we shall feel that the cornea of the other eye is instantly elevated; and that it thus rises and falls in sympathy with the eye that is closed and opened." I have made this experiment repeatedly, and not found my closed eye ascend when I closed the other: nor have my friends, who observed the cornea projecting at the closed eye, seen any ascent of it on my closing the other. Indeed, according to him, the closed eye ought already to have ascended when it was closed, and thus could not be felt or seen ascending when the other eye was closed. He says that, if, closing the eyes opposite a window and still seeing the light through the lids, we attempt to close them farther, we shall be in momentary darkness, because during the effort the eyeballs are then turning up. But there is sufficient reason for our darkness in the circumstance of the eyelids becoming thickly

folded during the attempt to close them farther. In fact, if my cornea is felt at this moment, it is found just where it was before; and the circumstance of light being seen, although the eyes were shut at first, disproves Sir C. Bell's statement, that, "at the instant in which the eyelids are closed, the eye-ball makes a movement which raises the cornea under the upper lid." He also says that, if the eyelid is prevented from closing by palsy or adhesion, the sudden approach of any thing to the eye causes the cornea to ascend. I have no doubt that it will ascend or descend, in order to get out of danger from the approaching body.

But the crowning wonder of the whole is that one of the obliques is not supplied by a nerve of the respiratory set. The superior oblique is supplied by the fourth — the pathetic or internal motor — a pair evidently of voluntary motion, but which is called by Sir C. Bell respiratory. Neither this, however, nor any other respiratory nerve goes to the inferior oblique, which is most unluckily supplied by the third only.[g] Further, the oblique muscle, which is not supplied by the fourth or any other respiratory (I am really ashamed of thus repeating the word in so absurd a sense) nerve, but by a nerve of voluntary motion, is the more important muscle of the two in turning the eye upwards and inwards. For, not only does he contend that this is its proper action (p. 312.), but that, when the superior oblique is divided and it and its nerve rendered useless,

[g] Sir C. Bell does not allude to this difficulty; but quietly advances an opinion which he may at any time adduce as his means of getting over it, should others discover it. He fancies that nerves relax as well as contract muscles; and "that the influence of the fourth nerve is, on certain occasions, to cause a relaxation of the muscle to which it goes," in which case the eye-ball must be rolled upwards. Thus the inferior oblique muscle acts because the fourth pair has relaxed the superior. The plain answer to this is, first, that the inferior oblique muscle acts not only when it is unopposed, but when the superior oblique is in action. Sir C. Bell speaks of their *combined action*, and it must move in this by the positive stimulus of some nerve. Secondly, it of course is furnished with a nerve, and this is a branch of the third — *not a respiratory pair*, but a pair of voluntary motion that supplies the straight muscles of the eye. In fact, to suppose a muscle, not belonging to a cavity or canal, to move without an exciting nerve, would be impossible; and, were such a muscle to have no nerve, its muscular structure would be useless — a merely elastic substance would have answered the purpose of lengthening under opposition and shortening when no longer stretched.

the lower gains in its power of elevating the ball, which turns upwards and inwards so forcibly as to be brought down again with difficulty by an animal (p. 314. sq.); and, although he had, throughout his paper, ascribed the elevation of the eyes, when closed, to the two obliques (p. 317.), he, at the end of it (p. 332.), ascribes the elevation to the inferior oblique only, and refers to the page in which he had ascribed it to both, as if he had there ascribed it to the inferior alone.

The straight and oblique muscles, there can be no doubt, are equally voluntary. The straight are clearly for the direction of the eyes, and we become acquainted with the distances, magnitudes, and positions of objects, by the sensations which accompany the motions of the muscles of the eye, or, in other words, from the consciousness of muscular effort. We owe this important principle to Bishop Berkeley, who, in his excellent essay on this subject [h], thus expressed himself more than a century ago: — "Now, it being already shown that distance is suggested to the mind by the mediation of some other *idea*, which is itself perceived in the act of seeing; it remains that we inquire what *ideas* or *sensations* there be that attend *vision*, unto which we may suppose the *ideas* of distance are connected, and by which they are introduced into the mind. And *first*, it is certain by experience, that when we look at a near *object* with both eyes, according as it approaches or recedes from us, we alter the disposition of our eyes, by lessening or widening the distance between the *pupils*. This disposition or turn of the eyes is attended with a sensation, which seems to me to be that which in this case brings the *idea* of greater or lesser distance into the mind. Not that there is any natural or necessary connection between the sensation we perceive by the turn of the eyes, and greater or lesser distance: but because the mind has, by constant experience, found the different sensations corresponding to the different dispositions of the eyes, to be attended each with a different degree of distance in the *object*: there has grown an habitual or customary connection between these two sorts of *ideas*: so that the mind no sooner perceives the sensation arising from the different turn it gives the eyes, in order to bring the *pupils* nearer, or farther asunder, but it withal perceives the different *idea* of distance which was wont to be connected with that sensation. Just as upon hearing a

[h] *An Essay towards a New Theory of Vision*, sect. 16. sqq. 1709.

certain sound, the *idea* is immediately suggested to the understanding, which custom had united with it." Dr. Wells, in 1792 [i], extended this principle of Berkeley's, and proved that the apparent direction also of an object which sends its picture to any given point of the retina depends upon the state of action existing at the same time in the muscles of the eye; and he adduced many and convincing proofs that it cannot be altered except by a change in the state of that action. Thus, an ocular spectrum impressed on any part of the retina does not appear to alter its position, when it is forcibly pressed aside in any direction; but, whenever the voluntary muscles act, it is referred by the mind to a different point of external space. That the apparent distances and positions of objects are suggested to the mind by sensations accompanying the motion of the muscles of the eyes, is a principle then clearly stated both by Berkeley and Wells. It has, however, by many been considered the discovery of Sir C. Bell, because he reproduced it, in 1823, above a century after Berkeley and thirty years after Wells, though he has not advanced a single original argument in its favour, and has unpardonably suppressed all reference to the philosophers by whose reasonings and researches it had been established. [k]

Prof. Wheatstone has recently made a series of curious experiments, from which it appears that the sensations which accompany the converging and the parallel motions of the eyes are so dissimilar, that it is highly improbable that these two sets of motions are effected by the same muscles. He is of opinion that the parallel motions of the eyes are governed by the straight

[i] *An Essay upon Single Vision with Two Eyes*. 1792. p. 56. sq. p. 70. sqq. of an edition of this and some other writings, with his autobiography, 1818.

[k] Let any one read Wells (pp. 55—57.) and Sir C. Bell (pp. 318—323.), and his eyes will rise most expressively, by the action, I presume, of the superior straight muscles.

Too many of the anatomical and physiological papers in the *Philosophical Transactions*, from the time of the first contributions of the glorious burner of John Hunter's precious and voluminous manuscripts to the present, reflect no credit upon those medical members of the council of the Royal Society who recommended their publication. But the poverty or errors of papers disfigure the Transactions, to my view, less than the parade of old facts and opinions as new, without the slightest reference to their authors; and this is a greater reflection upon the medical members of the council, when the real authors were distinguished Fellows of the Royal Society.

muscles, while the converging motions are regulated by the oblique. The experiments from which Sir C. Bell infers that the oblique are not voluntary muscles prove only that their functions are not the same as those of the straight muscles. If Professor Wheatstone is correct in the functions which he assigns to the oblique muscles, it is easy to see that they have an appropriate office under voluntary control, though their peculiar actions do not assist the straight muscles.

Light, like heat, is an agent by which all vegetables and animals are intended to be influenced. As the terms heat and cold are only relative, and no temperature is so low but that there might be a lower, and the plant, which lives in the snow only of polar regions, would still perish if the temperature were lower than it is; so light really exists in darkness, — no darkness might not be darker, and no plant or animal can be totally deprived of light. Deprived of light, a plant would lose its characteristic form, colour, taste, and odour, and puzzle the best botanist: persons deprived of light grow pale and sickly; but in this case, whether the place be a mine, a narrow street, or a prison, the want of fresh air, and in regard to prisoners the depressed condition of the mind, and occasionally the deficiency or bad quality of food, must also be taken into consideration: and, if pregnant women confined in dungeons often produce monsters, the state of mind cannot but be a powerful cause of the aberration. Dr. Edwards has proved that, by excluding tadpoles from the light, they will grow to double or triple the size that tadpoles usually attain, but are not metamorphosed into frogs. He thinks that the proteus anguinus, which, like tadpoles, has lungs and gills, is but the first stage of an animal which is prevented from becoming perfect by inhabiting the subterraneous waters of Carniola. He concludes therefore that light has a great influence upon the human body; and ascribes the observation of Humboldt, that, among millions of Caribs, Mexicans, Peruvians, &c., not one instance of deformity appeared, to the exposure of their body to light, and much of the sickliness of imprisoned persons and scrofulous children living in close streets to the want of light. (*De l'Influence, &c.* P. iv. c. 15.) "Vegetables, though they have no nerves, guided by light, open and close their flowers and their leaves." "In plants with compound leaflets," says Professor Lindley, "the leaflets fold together while the petiole is recurved at the approach of night; and the leaflets again expand and raise themselves at the return of day. In others the leaves converge over the flowers, as if to shelter those more delicate organs from the chill air of night. The flowers of the crocus and similar plants expand beneath the bright beams of the sun, but close as soon as these are withdrawn. The œnotheras unfold their blossoms to the dews of evening, and

wither away at the approach of day. Some silenes roll up their petals in the day, and expand them at night. The florets of numerous Compositæ, and the petals of the genus Mesembryanthemum are erect in the absence of the sun, but become reflexed when acted upon by the sun's beams." "Plants of corn, in which there is little indication of sleep when grown singly, exhibit that phenomenon very distinctly when observed in masses: their leaves become flaccid and their ears droop at night." "A flower removed from the shade will often expand beneath a lamp, just as it will beneath the sun itself." De Candolle found he could induce plants to acknowledge an artificial day and night by exposure to the light of candles. Still, Prof. Lindley remarks, there must be some other cause than light, because many flowers close in the afternoon while the sun shines on them, and the petals of others fold up under a bright illumination. (*Introduction to Botany*, book ii. chap. xii.)

Just, however, as different plants require different temperatures, and the protococcus nivalis flourishes and secretes in snow, so different plants require different degrees of light. Humboldt, near the Canary islands, saw a marine plant of a grass green brought up from a depth of about 190 feet, where the light could not have been stronger than that of a candle at the distance of a foot. He found several green plants growing in the dark mines of Freiberg; but there the atmosphere was peculiar, — charged with hydrogen or a large quantity of nitrogen; and Senebier remarked that plants do not completely lose their green colour in darkness, if they are supplied with a certain quantity of hydrogen, — an observation not verified in the experiments of Decandolle. (*Physiologie Végétale*, par M. Aug. Pyr. Decandolle. Paris, 1832. t. ii. p. 899. sq.)

Zoophytes prove themselves sensible to light; some by expanding or contracting according to its intensity, or by placing themselves on the side of a vessel where the light is strongest. One, the veretillum cynomorium, seeks the darkest places, and contracts as soon as light is admitted to it.

Most entozoa, living in the dark recesses of other animals and imbedded in what they feed upon, require no eyes, and are not known to have them. Nor the acephalous or bivalve mollusca, as the oyster, or the cirrhopodous, as the barnacle, the hind part only of which protrudes from the shell. Many minute polygastric animalcules seek and enjoy the light; and, on the front of their bodies, small red spots are generally discovered. Even monads, regarded as the lowest of animals, have them. In other infusoria these spots are united into one. These receive the impression of light only, and, as the polygastric animalcules move rapidly and prey on others, perhaps not merely light, but forms are distinguished. No nervous filament has hitherto been detected in such creatures: but, as they have impressions from an external organ, desire and will, they must have something equivalent to a nervous system. This is the first form of the eye in the larvæ of insects when the organ begins to develope, and in the young of higher animals; and, when an optic nerve is added, this is placed behind the pigment of the red spot, showing the spot to be the organ of vision. In the nais proboscidea, and many of the lower tribes of annelida, an optic nerve is added to the pigment: but nothing more is discoverable. Many of those entozoa or rather epizoa which live on the external parts of others, on the skin, eyes, gills, &c. as the ergasilus gibbus, which is attached in myriads to the gills of freshwater fishes,

have eyes, numerous or single, single originally, or several united into one, but lying flat on the surface, — sessile. So with most free annelida: in the planaria viganensis there is a single row of about forty eyes. In addition to the pigment and nerve there is a lens. In different species of gasteropoda, as the slug, snail, limpet, eyes are situated at the base, middle, or extremity of their tentacula. The eye of the helix pomatia has within its pigment a transparent semifluid substance, and even another transparent body shaped like a lens. The murex tritonis and voluta cymbrium have also an iris forming a pupil. Among the articulated animals we find the lucid spots already mentioned, called also simple eyes and stemmata; conglomerate eyes, or clusters of these; and compound eyes, or a large assemblage of small tubes each with its own humours, retina, and cornea; together with eyes supplied each with separate lenses and retinæ, but having one common cornea. Among myriapods we have examples of the conglomerate eye; in the scolopendra there are twenty contiguous circular lenses arranged in five lines, with one larger eye behind the rest, like a sentinel; in the millipede, there are twenty-eight, arranged in a triangle of seven rows, each having one eye fewer than the row above. In the larva state insects have only stemmata if they are destined for a complete metamorphosis; but, if to an incomplete, they have both compound and simple eyes. Some zoophytes, being free in one state have eyes, which they lose on being metamorphosed and no longer free, when eyes would be useless. Except some parasitic insects and five species of ants, all insects have compound eyes, generally one on each side of the head, forming a globular mass of from fifty to some thousands, even twenty or thirty thousand minute eyes closely pressed together, and placed on a central bulb which is a part of the optic nerve. They are cylinders or cones, while their external part or cornea is the base, usually hexagonal, like the cells of a honeycomb, because this form allows uniformity of arrangement with the greatest economy of space. The united bases or corneæ are an hemispherical convexity; under each cornea is an almost conical lens. Each cornea is covered by smooth epidermis, just as our cornea is covered by conjunctiva, with its apex backwards towards the nerve, and a portion of chorioid pigment lies between the cornea and lens, with an aperture in the centre, constituting a rudimentary iris, which in the grey dragon fly has been seen to contract and dilate; and between it and the cornea are a little space and a drop of aqueous humour. The pigment runs backwards around the lens, separating each cylindrical compartment. The apex of the lens is met by the end of a filament of the optic nerve, running through a vitreous humour; and Dr. Wollaston found the focal distance to correspond accurately with the length of the tube, so that an image falls exactly upon the retina. These multiplicities of corneæ in all directions compensate for the want of sensibility in the eyes of insects. There are often simple detached sessile eyes also, equally motionless: and the purpose of the presence of both kinds is unknown. There is no apparatus of defence, — no eyelids, eyelashes, or tears, except that hair sometimes grows from between the corneæ; and these are compensated for by the great hardness and insensibility of the cornea, which allows it to be brushed with the hairs of legs or other moveable parts. Branches of a trachea have been traced into each kind of eye. In the arachnida the optic nerve expands into a cup-like form behind a hyoloid membrane and vitreous humour.

The eyes of crustacea are compound and immoveable except in the higher orders, in which they are placed on peduncles and moved by muscles; and one crab has the peduncle jointed at one spot, so that the eye can be moved in various directions, like the arms of a telegraph. In those crustacea which are called monoculi, the eye is of the fourth class,— many lenses behind one cornea, and placed in a socket, in which muscles exist for its motion. Allusion has been already made to the eyes of mollusca. When they can be useful they exist, but are always simple and solitary; they have always a lens, and approach very closely to the eyes of fishes and higher vertebrated classes. The sepiæ, indeed, besides a large and very convex lens, exceedingly hard at its centre, have a hemispherical vitreous humour, a chorioid, an iris with a kidney-shaped pupil, but no cornea, the integuments of the head being continued over the iris, reflected upon the edges of its pupil, and covering the external surface of the lens.—Fishes have eyes similar to the sepiæ, but possess a cornea, which, as in all aquatic animals, on account of the small difference there can be between its refractive power and the water they inhabit, however great its convexity, is nearly flat. They require no aqueous humour, except a little to preserve the iris free. The vitreous is not a body of sufficient density to be very important. The globe is hemispherical, the lens nearly spherical and very dense, and more and more so towards its centre. It consists of concentric layers of fibres, the fibres of each layer being serrated and locked into another side by side. The pupil is large, and the iris nearly motionless. The outer shining layer of the chorioid passes over the front of the iris and gives it a pearly lustre; the dark inner layer lines its posterior surface. Their situation renders all eyelids and lachrymal apparatus superfluous; and they have only a covering of the common integuments over the cornea. The sclerotic is of extraordinary thickness and hardness, and contains fat between itself and the retina. As fish live in a dark medium their eyes are large, particularly if they live 300 or 400 fathoms below the surface. The eyes of fish which burrow in mud are small; sometimes rudimental or imperceptible. The optic nerves sometimes decussate, sometimes simply lie across each other, sometimes one passes through a hole in the other. Amphibious reptiles, being destined to live on land and in water, have eyes intermediate between those of fish and of land animals. Their eyes are large, possessed of little aqueous humour, and therefore the cornea is comparatively flat, especially in those which are the most in water; the lens is thick in the direction of the axis of the eye; as they are sometimes out of the water they have eyelids, the lower larger and more moveable than the upper, together with a third eyelid or membrana nictitans. In land reptiles, the structure recedes from that of the eye of fishes and approaches to what is observed in birds; the cornea is more convex, the aqueous and vitreous humours more abundant, and the lens less spherical; two moveable eyelids, a membrana nictitans, straight and oblique muscles, and a lachrymal apparatus exist. In some ophidian reptiles, as serpents, the skin of the eyelids passes over the eyes and their appendages, and this portion of it is therefore shed with the rest: one small tribe of them, comprehending eels, have a membrana nictitans like saurian reptiles. In some chelonian reptiles, as the tortoise and turtle, and some of the saurians, as the crocodile, a circle of imbricated plates of bone is seen at the fore part of

the sclerotic, and supports the iris: within the sclerotic of some there is fat. In the gigantic ichthyosaurus, which formerly inhabited the ocean, but is now extinct, the same is found. The chamelion has very projecting eyes, to which the light is admitted through a minute vertical slit in the skin, which forms but one lid, the upper and lower being united; and each eye can be turned in a variety of directions independently of the other: there is also a membrana nictitans nearly as large as in birds.

The wonderful adaptation which is observed throughout nature, in the most minute point, to the purpose for which every thing was intended, presents us in birds with eyes the most remote in form and structure from those of fishes, and exactly fitted for the rare medium which they inhabit; the difference between which and the aqueous humour of the eye is so great, that this is sufficient to refract the rays of light powerfully. The aqueous humour is, therefore, so copious that the cornea, which is thin, is very convex; and, to prevent the sclerotic from being unduly expanded, and the prominence of the cornea lost, a circular series of fifteen or twenty quadrangular, moveable, imbricated bony plates are placed around its edge, between the two plates of the sclerotic: from being imbricated, they are much less liable to fracture than a bony ring. The tough posterior part of the sclerotic forms a large hemisphere almost occupied by the abundant vitreous humour; while the lens, not being so requisite for refraction, is flattened, smaller, and less dense. The iris and lens are necessarily at a great distance from the cornea, by which arrangement the refracting powers are susceptible of great variation, and the animal sees well at the most different distances. Not only were these powers necessary, but a large field of vision; and therefore the cornea is very prominent, and the eyes of great size compared with the head, and placed laterally upon it. Yet they are less moveable than in quadrupeds; but the reason of this is the length of their neck and extreme mobility of their head. The chorioid coat, lined with a black pigment of globules with a transparent centre, sends a prolongation called marsupium or pecten, puckered and folded, from the entrance of the optic nerve through the vitreous humour, and to the capsule of the lens, for some purpose unknown, unless it be to supply copious vessels for secretion, to darken the eye in the blaze of the sun, or, if muscular, to affect the shape and position of the lens, and thus adapt it for vision in great variations of distance. The iris has various bright colours, and is wonderfully mobile, and thought to be voluntary, in parrots. The membrana nictitans, or moveable semitransparent fold of the conjunctiva at the inner corner of the eye, is of great size and moved by two strong muscles in order to keep the tears constantly diffused over the eye in the rapid course of birds through the air, and to protect it fully against sudden light. It returns to its place by mere elasticity. We have a rudiment of it in our own inner canthus. The eyes of mammalia agree generally with our own; but, as some of this class fly, some inhabit the water, some are amphibious, and some burrow in the dark, they are necessarily of great variety. They are generally small in those bulky animals whose food requires not to be discovered at a distance, as the elephant, rhinoceros, and hippopotamus: the eye of the elephant is not above two inches in diameter; of the whale, not above the 200th part of the length of its body. They are small in moles and shrews; so small in the mole, that Dr. Magendie

denied the existence of an optic nerve in this animal.* In the zemni, or blind rat, the integuments, overspread with hair and of uniform thickness, cover the whole side of the head, and under it a black spot only is found, a mere rudiment and useless. In these cases, the sense of hearing is extremely acute; and both it and other senses in the bat, which has very small eyes, though a nocturnal animal. For those which prey by night, as well as those which have to see at a distance in order to pursue or avoid pursuit, as the carnivora, rodentia, and ruminantia, have large eyes. The pupil is transverse in many ruminants whose head inclines downwards, so that they can see extensively to the side and backwards when feeding: while in those which spring from a height, or climb, it is frequently perpendicular, so that their vision is extensive upwards and downwards. In almost all the inferior tribes, just as is generally the case in fishes, reptiles, and birds, they are placed laterally in the head, with two independent fields of vision, the optic axes forming a very obtuse angle together, so as to give a very large view. As we ascend towards the quadrumana, the optic axes form a smaller angle,— the two fields of vision approach, so that both eyes can be directed simultaneously to the same object; and the same is noticed in nocturnal quadrupeds, and in owls; and in us the axes are more nearly parallel than in any other mammalia, the fields of vision coincide in almost all their extent, and precision of visual impressions is thus augmented. In carnivorous quadrupeds, the back

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* Not only did Dr. Magendie deny this, but M. Serres, doing the same thing, declared that the mole and several others saw by means of other nerves than the optic, and thus argued that one part of the nervous system could perform the functions of another. "The sense of smell," says he, "can be transported from one nerve to another, according to the ingenious remark of Professor Duméril. From the observations of Scarpa, Cuvier, Jacobson, and Treveranus, hearing may be partly performed by the fifth pair. From my researches on the mole, chrysochlore, shrew mouse, zemni, proteus, &c., these animals see by some other nerve than the optic. Is it not such facts as these that gave M. Cuvier the idea of the general law which he has stated, of the difference of the functions of nerves depending rather upon the different organisation of the parts to which they are distributed, than upon their own nature." Gall observes that M. Serres must have forgotten the remark in his treatise on the difference of nerves (*MON traité sur la différence des nerfs*, in his 4to work, t. i. p. 127.), that Cuvier disavowed this idea in his *Comparative Anatomy*, p. 492., where he says, "analogous parts constantly receive their nerves from the same pair in all animals, whatever be the situation of the parts, however circuitous the course which the nerve has to take. Analogous nerves have always a similar distribution: always go to the same parts. Even those small pairs whose distribution is the most limited, and which might easily be supplied by others, as the fourth and sixth, preserve their existence and office." Gall then states that he has examined the mole and found an optic nerve, though extremely small; and adds that M. Baily has confirmed his observations, and demonstrated the nerve to St. Hilaire and Cuvier. Naturalists now agree with Gall. (Gall, l. c. 8vo. t. vi. p. 307. sqq.)

part of the chorioid has not the black pigment of other parts, but a pigmentum lucidum or a tapetum, shining with a blue or green metallic lustre. In mammalia, to compensate for the smaller extent of motion in the head, the eye has more means of motion than in birds. In aquatic mammalia, the eye has many affinities with the structure of the organ in fishes. In cetaceous animals, for example, the cornea is flat, the aqueous humour inconsiderable; the lens large, dense, and spherical. Intermediate forms of the organ are observed in the semi-aquatic, — the walrus, seal, beaver, otter. "Thus," says my able colleague, "we observe these complicated optical instruments, the most universal and the noblest organs of sense, gradually advancing to perfection from the monad to the man, where all their internal essential parts, and all their external accessory apparatus, are the most exquisitely finished and adjusted; and it is chiefly through these means that he is enabled to provide for his wants, to acquire the materials of thought, and to enjoy the sublime spectacle of nature." — Dr. Grant, ll. cc. See also Dr. Roget, l. c.

CHAP. XXVII.

SLEEP.

"The faculties both of feeling and motion, possessed by the" brain, "are so fatigued by their exertions in the day, that rest is necessary during the night to recruit them by means of *sleep* [a] — the image of death," as it has been termed; for in it we cease to be cognisant of the world around and of our own existence, and lie motionless. Mechanical contact, temperature, savours, odours, light, and sound are no longer felt unless strong; nor the internal feelings of hunger, thirst, &c.; thought ceases, and, from the general suspension of volition, gravity, no longer opposed by contracted muscles, produces its full effect, the head falls forwards or to one side, the upper eyelid, the lower jaw, the extremities drop, and the body sinks, as far as circumstances allow it, into the horizontal posture. This state may come on in a moment, or in a more or less gradual manner, and it may come on gradually for a time and at length suddenly. If gradually, we feel tired; find attention and muscular volition more and more difficult, so that we imperfectly understand what we are hearing, reading, or thinking of, or what is passing around us: we speak slowly, imperfectly, and unconnectedly, till we cease to speak at all; we desire to think, perceive, and make the least exertion, no longer, — are drowsy. If at the same time we have a reason for keeping awake, we make great and repeated efforts to open our eyes, to elevate the lower jaw, and to raise and balance our head and trunk, perhaps to the great amusement of others: we take

[a] "Consult, besides authors hereafter to be recommended, Dr. Darwin, *Zoonomia*, t. i. Sect. xviii.

And Wienholt, *Heilkraft des thierischen Magnetismus*, vol. ii. p. 437. sqq.

Fr. Aug. Ammon, *Commentatio præmio regio ornata de somni vigiliarumque statu morboso*. Gott. 1820. 4to.

C. Fr. Heusinger, *De variis somni vigiliarumque conditionibus morbosis*. Isenac. 1820. 8vo."

But particularly Dr. Robert Macnish, *The Philosophy of Sleep*. Ed. 2. Glasgow, 1834.

the easiest position in our power, — that which approaches the nearest to the horizontal, so that we may have to make no muscular effort; we gape, and yawn; a degree of delirium [b] is experienced, from the impaired condition, short of suppression, of our feeling and attention. This delirium or wandering when we are between sleeping and waking is a much surer sign that we are about to get to sleep than the consciousness of the greatest drowsiness. A heaviness of the upper eyelid; smarting of the eyes, such as to give rise to the common remark to a sleepy person, that the dustman has thrown dust into them; peevishness, especially in children; chilliness; also precede sleep that does not come on suddenly. The breathing grows slower in two respects, — as to the intervals of the respirations and as to inspiration, and on this very account it becomes deeper, and takes place with increased sound: and in adults snoring is a common occurrence during sleep, and takes place if the inspirations are forcible, and if circumstances favour an open state of the mouth, so that the velum palati, being relaxed, is thrown into vibrations by the passing air, or if more or less of the tongue lies up against the palate, so that the nose is made to vibrate; and if the mouth is closed, palatal snoring will still occur should a portion of the tongue touch the palate, and snoring will be more and more nasal the greater this portion of the tongue. Like the respiration, the pulse grows slower and fuller. To exclude the light as much as possible, the pupil becomes contracted, and the eyes sometimes turn up or down. The temperature falls somewhat. The transpiration is found to increase; and, when persons are weak, this is shown by its occurring frequently to the amount of sweating as soon as ever they fall asleep. From this circumstance, and the cessation of drinking, less urine is secreted; and, from the motionless state of the lower jaws and tongue, and the absence of food from the mouth, there is less saliva and oral mucus; from the absence of light and the quiet state of the eyes and eyelids, less lachrymal secretion. But, except from such absence of stimuli which act in the waking state, I doubt whether secretion is lessened in sleep: that it is not necessarily lessened, is shown by the increase of perspiration. Dr. Macnish

[b] "De Pauw has some singular observations upon it in his *Recherches sur les Egyptiens et les Chinois*, t. ii. p. 1[illegible]."

contends that all other secretions are lessened, — the nasal, bronchial, and intestinal. The nose is certainly not blown during sleep; but only because we do not perceive its charge of mucus: on awaking, however, we find a handkerchief useful. In pulmonary affections there may be no expectoration during the night, but then a large quantity is discharged on waking. Diarrhœa may not disturb a patient while asleep, but a copious evacuation is common in this disease early in the morning. With the chaste of either sex, genital emission is common during sleep. In the morning the mouth is foul and the eyes gummy. But these circumstances probably arise from the lessened amount of the respective secretions from the lessened excitement, so that evaporation concentrates them.

The circumstance of our resisting sleep as long as we can keep our eyelids open, and falling asleep, when very sleepy, the moment we allow the eyelids to drop, is very striking, but explicable on the continuance of voluntary effort in the former case, and cessation of it in the latter.

There is less resistance to the cooling power and morbid effects of cold and injurious agents during sleep. Therefore persons cover their heads before going to sleep; and, when habit has not overcome the necessity for this, cold is continually caught from its neglect. A draught of air is far more dangerous in the sleeping state; and the back of the body appears less vigorous than the front, as a draught at the back is much more dangerous than in front. Agues are caught more readily if persons fall asleep.

In the healthy state, we awake refreshed with sleep, —

> "Tired nature's sweet restorer, balmy sleep."[c]

The transition from the sleeping to the waking state may, like the opposite, be sudden: but generally it is slow.[d] When sudden,

[c] Young's *Night Thoughts.*

[d] Milton exquisitely represents the slow approach of Adam's first sleep as causing him to imagine his existence was departing: —

> "Pensive I sat me down: then gentle sleep
> First found me, and with soft oppression seized
> My drowsed sense, untroubled, though I thought
> I then was passing to my former state
> Insensible, and forthwith to dissolve."

Parad. Lost, b. viii.

a few moments are required for us to recover from our surprise and find we are awake. When slow, we for a little while are sleepy, gape and yawn, but half open our eyes, scarcely perceive what is around us or understand what is said; and have imperfect power over the muscles, so that we stagger and perform all movements awkwardly: and, if still slower, the same delirium is experienced as while going slowly to sleep, and for a little longer we are still sleepy.

Sleep appears much more profound at the beginning than towards the end, and, I presume, because the fatigue is then greatest and gradually lessens as sleep continues. In the same manner, transpiration, we have seen, is at first greatest, and gradually lessens as the body loses its excess of fluid; and absorption gradually lessens as the body becomes charged with fluid.

In some diseases of the nervous system persons may pass many days, and even entire weeks, with little or no sleep. I have known this sleeplessness to be the only disease, and recur on several occasions in the same individual: usually after excessive corporeal or cerebral excitement. Great wretchedness, debility, and restlessness of body and brain took place.

The duration of sleep is various. Youth and young adults will habitually sleep soundly and uninterruptedly for eight or nine hours. Infants and old people sleep for shorter periods. Some persons are constitutionally sound and long sleepers: others light and short sleepers. Infants sleep far more in the twenty-four hours than adults: when very young, having but recently come into the waking state from the womb, they are awake but for short periods; and for very many months require to go to sleep several times, and for the first two or three years more than once, in the twenty-four hours. Old people sleep lightly and frequently; and altogether but little, unless lethargic disease comes upon them, which is very common.

I heard Baxter the coachmaker declare he never took more than three hours sleep during the most active period of his life. "The celebrated General Elliot"—"never slept more than four hours out of the twenty-four; and his food consisted wholly of bread, water, and vegetables." Sir John Sinclair mentions a James Mackay, "a remarkably robust and healthy man," "who died in Strathnaver in 1797, aged ninety-one, and only slept, on an average, four

hours in the twenty-four."—"Frederic the Great," as he is called, and the truly great John Hunter, "slept only five hours in the same period." Dr. Macnish, to whom I am indebted for these instances, says, "I know a lady who never sleeps above half an hour at a time, and the whole period of whose sleep does not exceed three or four hours in the twenty-four, and yet she is in the enjoyment of excellent health."[e] Sir Gilbert Blane states that General Pichegru informed him that, "in the course of his active campaigns, he had for a whole year not more than one hour of sleep, on an average, in twenty-four hours."[f] Sleep varies so much in intensity that a *dead* sleep of an hour may be an equal repose to an ordinary sleep of many hours. The celebrated De Moivre slept twenty hours out of the twenty-four; and Thomas Parr latterly slept away by far the greater part of his existence.[g]

We read that some persons have been able to sleep long whenever they wished. "Such," says Dr. Macnish, "was the case with Quin, the celebrated player, who could slumber for twenty-four hours successively." And "Dr. Reid could take as much food and immediately afterwards as much sleep as were sufficient for two days."

Independently of apoplexy, we have cases of extraordinarily long sleep. A woman in Henault slept seventeen or eighteen hours a day for fifteen years.[h] Another is recorded to have slept once for forty days.[i] A man named Samuel Chilton, twenty-five years of age, at Tinsbury, near Bath, once slept for a month: in two years he slept again for seventeen days, at the beginning of which period he took food, and had evacuations, but at length his jaws fixed: when he fell asleep the barley was sowing, and when he awoke he would hardly believe he saw it reaping: at the end of a year he fell into such another sleep: his farther

[e] l. c. p. 33. sq. He refers to Gooch for the story, which he very properly disbelieves, of a man, who "enjoyed good health and reached his seventy-third year," and yet "slept only for fifteen minutes out of the twenty-four hours; and even this was a kind of dozing and not a perfect sleep."

[f] *Medical Logic*, p. 83. 2d edit.

[g] Dr. Macnish, l. c. p. 35.

[h] *Medical Observations and Inquiries*, vol. i.

[i] Plott's *Natural History of Staffordshire*.

history is not given.[k] Mary Lyall fell asleep in the morning of the 21st of June, and did not awake till the evening of the 30th, and slept again the next day till the 8th of August, remaining motionless and without food from the first till seven days had elapsed, when she moved her left hand and pointed to her mouth, in consequence of which food was given her, which she took during the rest of her sleep: she heard nothing; and, though she instantly drew back her left hand when touched with the point of a pin, the right might be scratched till it bled without pain: she was bled, blistered, and plunged into cold water without sensation: her pulse for the first two weeks was generally 50; during the 3d and 4th about 60; and the day before she awoke 70 or 72: her breathing was almost imperceptible, but in the night occasionally strong as in a person asleep: she gave signs of hearing about four days before she awoke; and afterwards recollected nothing that had occurred in her attack,— neither the blistering, bathing, nor eating; and had the idea only of having passed a long night in sleep.[l]

A lady at Nismes would sleep from sunrise, whatever the season of the year, till near noon; and again immediately after noon, not waking till between seven and eight at night; but she now remained awake till sunrise. If the attack lasted six months, she was free for six months; if for twelve, she was free for twelve. The affection gradually declined, so that she lived free from it many years, and died at eighty-one.

Dr. Macnish mentions one "Elizabeth Orvin, who spent three fourths of her life in sleep."

In hysteria, I saw a young lady who slept for six weeks and recovered: and her twin sister had slept for a month; but, whether from not being well supplied with nourishment and warmth I cannot say, she died before I saw her, and on inspection nothing but inanition and bloodlessness was found.[m]

Elizabeth Perkins, in 1788, fell into a deep sleep from which nothing would rouse her: at the end of eleven days she spontaneously awoke, and went about as usual; but fell asleep again in a week, remained so for some days, and, with occasional intervals

[k] *Phil. Trans.* 1694.

[l] *Transactions of the Royal Society of Edinburgh*, 1818.

[m] See my clinical lecture in the *Lancet*, March 12. 1831.

of waking, dozed for several months and died. A poor paralytic man at Kirkheaton, twenty years of age, was seldom awake more than three hours in the twenty-four for a year: once he slept for three weeks, breathing calmly, but incapable of being roused and of eating or drinking.

A lethargy of several days before apoplexy is sometimes observed. Some are constitutionally or temporarily very susceptible of the influence of soporifics. I have seen a person destroyed by a single dose of a third of a grain of muriate of morphia; and two or three from a grain, although they had recently taken doses of half a grain, and even a grain, with little effect. Again, in morbid irritability, as in delirium without strength, large quantities are borne. I have seen a grain of muriate of morphia, after its exhibition in more distant doses, taken every hour for forty-eight hours, with not the least effect. Sometimes, without dying, persons remain a long time asleep after soporifics. Dr. Macnish refers to a child, near Lymington, that was thus sent to sleep for three weeks.

I believe that most adults require from six to eight hours sleep. Some require nine or ten. In proportion to the exhaustion is sleep required. Therefore in debility, as after a severe disease, convalescents, though making no cerebral or muscular exertion, sleep a great deal, and find the utmost invigoration from it. The longer the waking state is protracted the greater, both absolutely and proportionally, is the exhaustion, whence one advantage of early hours, which is expressed by the adage,—one hour's sleep before twelve is worth two after. If a person rises proportionally late, he certainly cannot suffer from this course; and if he suffers, it must be ascribed, provided there is no debauch in the case, to his loss of the influence of so much solar light and morning air. One of our judges, Lord Mansfield, is said to have questioned every very old person who went into court respecting his habits: and found that some had lived in towns, some in the country, some were hard livers, some temperate, and all agreed in only one point,—that of having been early risers through life. I, however, have known several very old persons who had always sat up late, though not in vicious indulgence, and risen late.

The Rev. Mr. Wasse, rector of Aynho in Northumberland, ascertained, in a variety of instances, that we are nearly an inch taller on rising in the morning than on going to bed; and the

fact is explained by the intervertebral substances recovering their elasticity during the removal of pressure in the night.[u]

Too much sleep produces headach, heaviness, and dulness: too little, feebleness, intellectual and muscular; thinness; indifference of the feelings, so that elephants are tamed by being prevented from sleeping; headach, and various unpleasant feelings in the head, chilliness and feverishness, and at length an inflammatory state of the brain. Studious young men too frequently disregard the law of nature, — that a certain quantity of sleep is requisite for cerebral and general vigour. They fancy that far less sleep than people usually take is sufficient; and instead of eight hours, which most require, especially in youth, take but six, or even fewer. The result of this is sooner or later felt severely; study becomes more and more difficult, and, at last impossible; constant uneasiness, tension, pain, heat, throbbing in the brain are experienced; perhaps sleep becomes very difficult; general weakness is felt, and too often inflammation of the brain, or typhus, occur, or some other disease, the causes of which would have been inoperative but for the exhausted and excited condition of the system to which they were applied. So many of the best of our young men fall into these circumstances every winter, and thus, if they happily do not die, lose eventually more time than they had stolen from sleep, to say nothing of the minor efficiency of their exertions while they can study than if they thoroughly refreshed themselves by a natural allowance of repose, that I find it a duty earnestly to point out this at the beginning of every session in University College; to urge that all excess, however free from vice, and even if it proceed from virtuous feelings, is followed by bad consequences; and I can with truth add that such is the industry and thirst for knowledge and intellectual distinction, such the correctness and good feeling of the very large majority, that I never spend more than a moment in guarding the freshmen against idleness, vice, and bad practices. There can be no question that study after repose is more efficient than before it. The brain must be more vigorous when refreshed than after the excitement of the day. Many prefer night study, and in the winter it is more convenient; but, in the

[u] Dr. Macnish, p. 38.

summer, early study is equally convenient; and those who have acquired the habit of night study have only to persevere in retiring early, and rising at a fixed early hour, and they will after a time find the morning sun tell better than the midnight oil. Some commit the error of rising very early, without going to bed proportionally soon: and the result is of course the same as if they sat up late and rose at ordinary hours; they go about weak, feverish, and stupid the whole day, and are absolutely knocked up in the evening.

The effect of too little sleep upon the face is very striking: sailors, who have their rest broken at short intervals, acquire an old look.

The power of habit over sleep is very great. Within certain limits it will lessen or augment the amount of sleep necessary; but these limits differ constitutionally in different individuals, and must be influenced by the habitual amount of exertion. Any one may acquire the habit of dividing his sleep, so as to take less at night, and a portion previously in the day or evening. Some become accustomed to have their rest broken at short intervals, and able to sleep directly they wish: they acquire the habit also of waking on the least noise; that is, of sleeping very lightly. "Seamen and soldiers on duty sleep when they will and wake when they will. The Emperor Napoleon was a striking instance of this. Captain Barclay, when performing his extraordinary feat of walking a mile an hour for a thousand successive hours, obtained at last such a mastery over himself, that he fell asleep the moment he lay down."[o] By habit we wake invariably at a certain hour, however late we may retire; until, by repeatedly retiring late, the system greatly feels the want of rest: on the other hand, a person accustomed to go to sleep at a certain hour, may oversleep himself in the morning, but becomes drowsy at his usual time in the evening. Habit enables us to sleep in unfavourable circumstances. "An old artilleryman often enjoys tranquil repose while the cannon are thundering around him: an engineer has been known to fall asleep within a boiler, while his fellows were beating it on the outside with their ponderous hammers; and the repose of a miller is no wise incommoded by the noise of his mill."—"It is common for carriers to sleep on

[o] Dr. Macnish.

horseback, and coachmen on their coaches."[p] "Nay, silence itself may become a stimulus, while sound ceases to be so. Thus a miller being very ill, his mill was stopped that he might not be disturbed by its noise; but this, so far from inducing sleep, prevented it altogether; and it did not take place till the mill was set a-going again. For the same reason, the manager of some vast iron-works, who slept close to them, amid the incessant din of hammers, forges, and blast furnaces, would awake if there was any cessation of the noise during the night."—"A person who falls asleep near a church, the bell of which is ringing, may hear the sound during the whole of his slumber, and be nevertheless aroused by its sudden cessation[q]:" and a person, sent to sleep in a church by a stupid sermon, generally awakes as soon as the preacher's humdrum is at an end.

The ordinary cause of sleep is fatigue. The activity of the day exhausts the powers of the brain—feeling, understanding, and will, and the brain sleeps. The greater, in point of duration or intensity, the activity, the greater the disposition to sleep, unless the exhaustion has produced aching or irritation, — morbid conditions, which, destroying the course of health, may prevent sleep. It matters not whether the activity has been volition, passion, sensation, or reflection. Exhaustion of one part of the encephalo-spinal system exhausts the rest; nay, so bound up together are all parts of the body,—the brain and the rest, that fatigue of the brain exhausts all other parts, and fatigue of any part will impair the powers of the brain, and great muscular exertion therefore of any voluntary part exhausts the vigour of the mind. No one thinks well who is fatigued by exercise, and nothing causes sleep at night more than good exercise in the day. All studious men, who are real thinkers, require a large allowance of sleep; and find a great difference in the soundness and urgency of sleep after a day of intellectual labour, and a day accidentally spent in the shallow prattling and reading common to the greater part of the more expensively, but not better, educated persons who fancy themselves to possess cultivated understandings; or in the performance of what is the daily routine of the majority of popular, and probably fashionable, practitioners, who are destitute of sound knowledge and strangers to reflection and study, and yet impu-

[p] Dr. Macnish. [q] Dr. Macnish.

dently assume the highest importance, and disparage those who read, observe, and reflect, and are anxious to advance the general good rather than their own little interests. The exhaustion being greater before sleep has remedied it, the beginning of sleep is necessarily the soundest part, and persons are less easily roused at the early part of the night; and, after sleep, light at first finds the eyes so sensible that it is disagreeable. Emotion, continued and at length wrought up to the highest pitch, will induce sleep: whence persons condemned almost always pass the night in sound sleep before the morning of their execution, and generals sleep on the eve of their great battles. Severe pain, or a too vivid sensation, leaves drowsiness. Exhaustion of the brain by defective support of its nutritive functions equally produces sleep as over exertion of its functions. Loss of blood, purging, starvation, cold, diseases that impair nutrition or cause exhaustion by general excitement, produce sleep, perhaps coma; young infants and old people frequently require stimulants and nutriment to rouse them from coma. Cold will induce a fatal sleep; yet, if the cold is not powerful enough to produce torpor, it will keep a person awake by the disagreeable sensation. Every one must have been unable to sleep from not having sufficient bed-clothes on a cold night; and cold feet frequently prevent repose.

Defective moral and intellectual excitement incline to sleep: stupid and passionless people are generally great sleepers, and a good method of getting to sleep is to think of nothing, — to turn aside from every thought that presents itself on the pillow. The withdrawal of all causes of sensation powerfully contributes to sleep: and all animals, when inclined to sleep, place themselves in a position which shall require no exertion of volition, and retire from and exclude as much as possible all external excitement.

The excitement of the brain may be reduced and thus sleep brought on by impressions on the senses just sufficient to withdraw attention from every feeling and thought, and yet insufficient to maintain much activity. A discourse stupid or delivered monotonously, a dull book or one not understood, is pronounced sleepy from its effects; the murmur of a rivulet and the hum of bees; the sight of any thing waving, as of a field of standing corn or of the hand drawn up and down before the face by a mesmeriser, attracting attention much more than an

object at rest and yet exciting but little; induce sleep, the former acting by the ear, the latter by the eye; and gentle friction is equally effectual by means of touch. I know a lady who often remains awake in spite of every thing till her husband very gently rubs her foot: and, by asserting to a patient my conviction that the secret of an advertising *hypnologist* whom I allowed to try his art upon the sleepless individual, and which he did for a time successfully, was to make him gently rub some part of his body till he slept, he confessed this to be the fact. Boerhaave acted on the same principle in regard to another sense, when he directed water to be placed near a sleepless patient, so circumstanced that it might drop into a brass pan. Gentle motion acts by an impression on the same sense; and a combination is of course still more effective, whence experience has taught nurses to rock, and otherwise gently agitate infants, while they hum them to sleep.

Most of the substances termed narcotic have a property of inducing sleep and stupor; they have the property of inducing also giddiness, confusion, headach, delirium, and heat and throbbing: but some narcotics produce few or more of the other effects rather than sleep. Narcotics lessen sensibility throughout and indeed affectibility, possessing a general hostility to all vital properties. Yet many, if not all, stimulate in moderate quantities. Opium augments the pulse and the heat, even in the head; excites the intellect and feelings; gives headach; and renders noise intolerable: strychnine causes tetanic spasms: tobacco excites sneezing: very many narcotics occasion smarting and burning.

Impure air appears narcotic and disposes to sleep. Heat has the same power, probably by relaxing; for a certain proximity of particles, and as it were tension of structure, is indispensable to vigour and activity. Heat may also act by overcharging the head with blood, partly through relaxation of vessels, partly, as some think, by expanding the blood itself. Whatever overcharges the head, as the reversed erect posture, has the effect of causing heaviness and stupor; and thus by lying flat on a revolving millstone, with the head towards the circumference, the centrifugal force accumulates blood in the head sufficient to produce sleep and at last apoplexy. Whatever else than blood compresses the brain has the same effect; for instance an accumulation of serum, depression of bone, and, when the bone has been deficient in an individual

through accident, pressure upon the brain with the hand at once sends the person to sleep. A full meal causes drowsiness as long as the food is in the stomach, perhaps from the great activity of the organ, so that, from the general sympathy, the brain among the rest is drained of its power: some ascribe a little to the more difficult expansion of the chest, and consequent accumulation of blood in the head. Fat and plethoric people are drowsy, and in them there is excessive fulness of the blood-vessels of the head from plethora and from the obstruction produced by difficult respiration.

The causes of waking are the opposite of those of sleeping. The accumulation of vigour gradually proceeds while sleep lasts, till the brain is spontaneously active again. But, before this, we may awake from an external excitant, to whatever sense it may be applied; from any internal causes of feeling, mental, or in the body at large; or from excitement having been so strong before sleeping that the brain will not remain torpid; from excitement of the nutritive functions of the brain, its circulation, evolution of heat, &c.; from the agency of certain substances which possess the property of keeping the mind active, as tea, coffee, which may prevent sleep altogether or cause it to be short.

The proximate cause of sleep or the condition of the brain in it has been variously viewed. Some have fancied the brain compressed, and compression will disqualify the brain for its functions and cause sleep, even coma, apoplexy, and death: but there is no proof or even probability of this in ordinary sleep. Blumenbach says, he thinks that sleep "probably consists in a diminished or impeded flow of oxygenated (arterial) blood to the brain; for that fluid is of the highest importance, during the waking state, to the re-action of the sensorium upon the functions of the senses and upon the voluntary motions.[r]

[r] "Those who wish to know and compare other opinions upon the causes of sleep, may consult,

M. de Grimaud, *Mémoire sur la Nutrition.* Petersb. 1789. 4to. p. 194.

H. Nudow, *Versuch einer Theorie des Schlafs.* Köningsberg. 1791. 8vo.

Steph. Gallini at the end of his *Saggio d'Osservazioni sui nuovi progressi della Fisica del Corpo Umano.* Padua. 1792. 8vo.

Mauduit, in Fourcroy, in the *Médecine Eclairée, &c.* t. iv. p. 273.

T. Chr. Reil, *Functiones Organo Animæ Peculiares.* Hal. 1749. 8vo. p. 108.

"The influx of blood," he continues, "is diminished by its derivation from the brain and congestion in other parts; it is impeded by the pressure of foreign matter upon the brain, whether from serous or purulent collections, from depression of fractured bones, &c."

"Besides other phenomena which accord with this explanation, especially those of hybernating mammalia[s], is a very remarkable one which I witnessed in a living person whose case was formerly mentioned, — that of the brain sinking whenever he was asleep, and swelling again with blood the moment he awoke.

"This opinion is likewise strengthened by the production of continued watchfulness from congestion of blood in the head."

Now it is certain that the supply of arterial blood to every part, and especially to the nervous system, is requisite to its functions and its life, and that in proportion to the activity of a part is the activity of its supply of arterial blood. Analogy, therefore, renders it extremely probable that, during the inactivity of sleep, the brain, having less occasion for arterial blood, has a less vigorous circulation than during the waking state; and we know that whatever diminishes the ordinary determination of blood to the brain, or impairs the movement of the blood through it[t], disposes to sleep. But, although this be

L. H. Chr. Niemeyer, *Materialien zur Erregungstheorie.* Götting. 1800. 8vo. p. 71.

Troxler, *Versuche in der Organischen Physik.* p. 435.

Brandis, *Pathologie,* p. 534."

Cullen, *Physiology,* p. 124. sqq.

Adelon, *Physiol.* t. ii. p. 292. sqq.

Dict. des Sc. Méd. t. xix. p. 348. sqq.

Bourdon, *Principes de Physiol.* l. 6. p. 785. sqq.

[s] "*v. c.* Of the alpine marmot, of which Mangili treats in Reil's *Archiv.* vol. viii. p. 466. sqq.

[t] As arterial blood when at rest acquires the venous character, and the slower its motion the greater is its tendency to assume this character, it is evident that in congestion of blood, by which is meant simply an unusual quantity of blood in the vessels of a part, not flowing with its usual freedom, the part affected has not its proper supply of perfectly arterial blood. Hence congestion in the head must, even from this cause alone, produce drowsiness, to say nothing of the effect of pressure on the cerebral substance.

granted, it must be viewed, not as the cause, but as a circumstance, or, in fact, a consequence, of ordinary sleep. Increase the activity of an organ, you increase its circulation; diminish its activity, you diminish its circulation. The alteration of circulation is usually not the cause but the consequence; necessary, indeed, to the continuance of the altered degree of activity in the organ, but not the cause. The degree of activity of any part, and the degree of its circulation, are exactly and un[illegible]ably correspondent. If the circulation through a part be mechanically increased or diminished, the sensibility and activity of the part will, doubtless, be proportionally increased or diminished. This example occurs in hemorrhage. Frequently both are affected simultaneously, — when diarrhœa renders the surface pale and cold, both the blood is sent more sparingly to it, and the energy of its vessels is diminished by the increase of energy in those of the intestines. But, in ordinary sleep, the diminished circulation appears only the consequence, for activity is always followed by inactivity. Stimulate a muscle separated from the body, it contracts, but it soon refuses to do so; after a little rest, it again contracts upon the renewal of the stimulus. The case of the brain is analogous; and when, after its daily activity, it falls asleep, the diminution of its circulation consequently ensues. The influence of sleep upon the cerebral circulation is shown by the headach and other marks of congestion which follow too much sleep. Boerhaave mentions a student who took a fancy that sleep was the natural state of man, and so slept eighteen out of the twenty-four hours, till he died of apoplexy. The horizontal posture will not explain these ill effects, because persons with spinal disease will lie a year upon the back without them.

Sleep is an inactive state of the brain, resulting ordinarily from mere fatigue of the organ through its activity: though pressure, want of proper blood, narcotics, &c. or want of exciting causes, may prevent activity, and thus induce sleep.[a] The case

[a] The most silly discussions may be found in old authors and modern twaddlers (see, for instance, *Isis revelata*, a book soon to be quoted) about the state of the soul in sleep. " There have been great disputes," says Gall, " upon the question, whether the soul can ever exist, as in sleep, without feelings or ideas? If we lay aside all vain metaphysical subtlety, the answer is very easy. In this life the soul receives its feelings and ideas by means of cerebral organs; when these

of the brain is the same as that of voluntary muscles. If these are laid bare and freely stimulated, they at length cease to contract; after a little repose, they obey a stimulus again. The brain may be kept awake by strong exciting causes long after it would have sunk into inactivity; but at length no stimulus will rouse it and sleep is inevitable. Exhausted soldiers sometimes sleep as they march, or sink on the ground in deep slumber amidst the roar of cannon. Still more readily will the young. During the battle of the Nile some boys fell asleep on deck in the heat of that dreadful engagement.[v]

In sleep the function of the brain is suspended, and, if it is perfect, there is no sensation, consciousness, thought, emotion, or volition: but the degree of suspension is extremely various. In ordinary sleep the mind is susceptible of sensations, and able, if these are unpleasant, to make an effort to remove their causes; — whether to remove the uneasiness of impeded circulation in the lungs by breathing, or to draw away the hand when tickled, or change our position, as some continually do in sleep. One or more faculties is often active, and one idea associates with it another, intellectual or moral, so that we dream; but the activity of the mind is partial, and, though we are able occasionally even to reason correctly in our dreams, we are not sufficiently

organs are completely inactive, the soul can have neither feelings nor ideas. Deep and complete sleep is a temporary cessation of personality (*moi*)." (ll. cc. 4to. vol. ii. p. 454. 8vo. t. ii. p. 506. sq.) By soul Gall meant cerebral power: but he wrote cautiously, as in Austria, Italy, and France, catholics are not contented to base our hopes of a future life upon Scripture, but insist on the existence of a soul to make Scripture probable.

[v] Dr. Macnish.—Blumenbach and Cabanis call sleep a function. The former says, "Sleep is a completely periodical function, by which the intercourse of the mind and body is suspended, and whose phenomena correspond, if any do, with the supposition of a nervous fluid." To say intercourse of mind and body, and not activity of brain and its dependences,—the rest of the encephalo-spinal system, and to say nervous fluid, is antiquated nonsense. Cabanis's words are, "Sleep is not simply a passive state, but a peculiar function of the brain." The answer to both these writers is, that "the cessation of a function cannot be a function." How different is the language of Gall: "Sleep is merely in the activity, the perfect repose of the brain in health. During this suspension of the cerebral functions, the brain acquires new force, and, on waking, its functions take place readily." l. c. 8vo. t. i. p. 210.

ourselves to discover the incompatibility of many circumstances which we fancy. In a higher degree of activity, we answer questions put to us, although often ridiculously, as our deficiency of mental power prevents us from keeping our associations in a proper train; and we sometimes even perform a regular series of movements. Somnambulism is but imperfect and partial sleep. In it persons walk and even perform a variety of other actions, without hearing or seeing, or consciousness of their situation, so that they fall over things placed in their way, or down a descent. They will sometimes write excellent letters, compose good verses, and perform accurate calculations, in this state, and on being roused into consciousness know nothing of what has happened. This state generally occurs in sleep, but it occasionally seizes persons awake, and is then termed ecstasis.[w] This is by no means uncommon at the commencement or termination of epileptic or hysteric paroxysms. In an opposite morbid affection, the patient is conscious and sensible of every thing around, but unable to move, or give the least sign of life.[t]

Dreaming and mental activity of all degrees in sleep, from merely turning in bed, to talking, walking, and composing, are partial activity of the brain. " Almost all physiologists agree," says Gall, " that in dreaming animal life is partially active. They are right, and yet they deny the plurality of organs! But dreams cannot be conceived without the hypothesis of this plurality."

" When, in sleep, particular organs of animal life become active, the sentiments and ideas which depend upon them must necessarily be awakened; but, in this case, the activity is independent of the will.

" When one organ only is active, the dream is simple: the object of our love is embraced, harmonious music is heard, we fight our enemies, accordingly as one organ or another is performing its functions.

" The more organs are in activity at once, the more the action of the dream will be complicated or confused, and the more incongruous will these be.

[w] A remarkable example is given in the *Psychological Magazine* of a young lady thus taken for dead, and after the funeral hymns were sung, &c. discovered to be alive by a sweat breaking forth at the moment she found the lid of the coffin was about to be nailed down.

"When the organs are fatigued by the waking state and exertion, we usually do not dream during the first hours of sleep, at least unless the brain is very irritable. But, in proportion as the organs become refreshed, they are more disposed to enter into activity, whence towards the approach of rising, we dream more and with greater vivacity."

"How is it that in a dream certain faculties occasionally display more energy than in the waking state? What precautions do we not take to meditate profoundly on a subject. We prevent all external impressions, we put our hand before our eyes, we shut ourselves up, to concentrate all our attention on a single point. The same thing takes place in certain dreams. All the vital energy is concentrated on one organ, or upon a small number of organs, while others are in repose; so that the energy of the former becomes necessarily more energetic. The sentiments and ideas excited in a dream are, in some cases, completely disengaged from all external mixture. We therefore cannot be astonished if some, like Augustus La Fontaine, make admirable verses in their sleep, or like Alexander draw out the plan of a battle; if others, like Condillac, solve difficult problems; if on waking in the morning some, like Franklin, find a work completed which had been projected on going to bed; if in sleep the true relations of things are discovered, which in the tumult of sentiments and ideas had defied our sagacity."[x]

In ordinary dreaming, our conceptions of objects of sense

[x] ll. cc. 4to. vol ii. p. 454, sq. 8vo. t. ii. p. 506, sqq. Cabanis relates that Franklin had on several occasions been informed in his dreams of the issue of affairs in which he was engaged. His vigorous mind, otherwise free from prejudice, says Cabanis, could not quite secure him from a superstitious notion with respect to these premonitions. He did not take into consideration that his profound prudence and rare sagacity still characterised the operations of his brain during sleep. It is also related of Condillac that, while writing his *Cours d'Etudes*, he was frequently obliged to leave a chapter incomplete and go to bed, and that, on awaking, he found it, on more than one occasion, finished in his head. Voltaire assures us that, like La Fontaine, he many times in his sleep made verses which he remembered on waking. Tartini composed his *Devil's Sonata* in a dream, in which Satan appeared and challenged him to a competition on his own fiddle. Coleridge prefaces his poetical fragment called *Kubla Khan* with the following account of himself: — "In the summer of the year 1797, the author, then in ill health, had retired to a lonely farmhouse between Porlock and Linton, on the Exmoor confines of Somerset and Devonshire. In consequence of a slight indisposition, an anodyne had been prescribed, from the effects of which he fell asleep in his chair, at the moment

are always far stronger than when we are awake: we always conceive with an intensity equal to sensation, — an impossibility in the waking state, unless under extraordinary excitement. — In sleep-waking, the conceptions have been so strong that an archbishop of Bordeaux declares of a young man, whose case will soon be related, that, dreaming he had just emerged from a stream, he shivered, his teeth chattered, he begged for brandy, and, on receiving water instead, again asked for brandy, took a glass of strong liquor, felt refreshed, and without waking fell into a perfect sleep. In sleep, things are sometimes remembered and spoken of, which had been forgotten: and we sometimes dream of our previous dreams, forgotten perhaps in our waking state: if we have remembered them when awake as dreams, we may dream of them as dreams, and sometimes, without having awakened after a dream, we dream on, dreaming again that the first was really a dream.[y] — Another instance of increased

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that he was reading the following sentence, or words of the same substance, in Purchas's *Pilgrimage*: 'Here the Khan Kubla commanded a palace to be built, and a stately garden thereunto: and thus ten miles of fertile ground were enclosed with a wall.' The author continued for about three hours in a profound sleep, at least of the external senses, during which time he has the most vivid confidence that he could not have composed less than from two to three hundred lines; if that indeed can be called composition in which all the images rose up before him as things, with a parallel production of the correspondent expressions, without any sensation or consciousness of effort. On awaking he appeared to himself to have a distinct recollection of the whole, and taking his pen, ink, and paper, instantly and eagerly wrote down the lines that are here preserved. At this moment, he was unfortunately called out by a person on business from Porlock, and detained by him above an hour, and on his return to his room, found, to his no small surprise and mortification, that, though he still retained some vague and dim recollection of the general purport of the vision, yet, with the exception of some eight or ten scattered lines and images, all the rest had passed away like the images on the surface of a stream into which a stone had been cast, but, alas! without the after restoration of the latter."

"Henricus ab Heer mentions the case of a student at a German University, who having been very intent on the composition of some verses, which he could not complete to his satisfaction, rose in his sleep, and, opening his desk, sat down with great earnestness to renew his attempt. At length, having succeeded, he returned, went to bed, after reciting his composition aloud and setting his papers in order as before." (*Isis revelata*, vol. i. p. 310.) "See what Hollman has related of himself in this particular. *Pneumotolog. Psycholog. et Theol. Natur.* Gotting. 1770. 8vo. p. 196."

[y] Dr. Macnish, l. c. p. 87.

excitement in dreaming is the extreme rapidity of conception, so that a succession of events may be crowded into a dream which we are certain cannot have lasted more than a few moments — a rapidity which takes place in the waking state only under the strongest excitement, as in the fear of instant death "Persons recovered from drowning have mentioned," says Dr. Macnish, "that in the course of a single minute, almost every event of their life has been brought to their recollection."[z] Some dreams have been singularly prophetic, from the extreme intelligence of the dreaming brain: in other instances, as when the prevision has related to the individual's death, the strong impression on the mind may have worked the fulfilment of the prediction: in others there may have been mere coincidence, but the coincidence has been most extraordinary. The greater part, however, of dreaming prophecies are never fulfilled.

The impression from dreams sometimes continues for life, especially from the dreams of childhood, and sometimes its events are afterwards confounded with reality.[a] We always wake from a dream in the mood of our dream: and, on waking from a terrific dream, emotion and unconsciousness that all was a dream have continued for a short time so powerful, notwithstanding the perception of all objects of sense around, as to cause the individual to jump out of window or to commit murder; sometimes insanity has resulted, and sometimes, as from strong emotion in the waking state, the cure of some disease.[b]

It is an error to suppose that our dreams are a mere repetition of sentiments and ideas previously experienced. Man may invent in his sleep just as when awake: for the internal sources of our sentiments and ideas are the same, whether we are asleep or awake.[c]

Dreams are no doubt forgotten as well as remembered: and, what is curious, we not only sometimes forget our dreams till we dream again, when the same things are recognised, with or without our knowing that they had been dreamt. We may dream of things as having been dreamt before, when, on waking, we cannot remember the circumstance.

To suppose, with some, that sleep is always accompanied by

[z] l. c. p. 62. [a] Dr. Macnish, l. c. pp. 46. 102.

[b] *Phil. Trans.* vol. ix., for such a cure of dumbness.

[c] Gall, ll. cc. 4to. vol. ii. p. 454.; 8vo. t. ii. p. 506. sqq.

dreams, though not remembered by us[d], is a mere assumption and indeed very improbable ; and it is the offspring of another assumption, — that we have souls, it being settled that souls are sleepless things.[e] Perfect sleep must be free from them; though slight dreaming stands on the same footing with coughing, and cannot be considered sufficient to constitute disease. Some always dream; some never.

In Locke we find the following passage: — "I once knew a man that was bred a scholar, and had no bad memory, who told me, he had never dreamed in his life till he had that fever he was then newly recovered of, which was about the five or six and twentieth year of his age. I suppose the world affords more such instances."[f] "For many years before his death, Dr. Reid had no consciousness of ever having dreamed."[g] The rev. Mr. Jesse, of Margaretta, in Essex, informs me that he knew a carpenter who never dreamt till after a fever in his fortieth year; and, as he before never could be made to understand what dreaming meant, so when he first dreamt he was as much surprised as perhaps Adam was when he first felt himself going to sleep. He was a man of a remarkably good, quiet, and plodding disposition.

We occasionally know a dream to be a dream and even act against it: as when Dr. Reid, finding himself subject to frightful dreams, determined to acquire the habit of remembering their

[d] "Consult Kant, *Critik der Urtheilskroft*, p. 298.; and *Anthropolog.*, p. 80."

[e] Locke reasons powerfully on this point: "'The soul, during sound sleep, thinks,' say these men." — "Methinks, every drowsy nod shakes this doctrine." — "Nature never makes excellent things for mean or no uses; and it is hardly to be conceived that our infinitely wise Creator should make so admirable a faculty as the power of thinking, that faculty which comes nearest the excellency of his own incomprehensible being, to be so idle and uselessly employed, at least a fourth part of its time here, as to think constantly, without remembering any of those thoughts, without doing any good to itself or others, or being any way useful to any other part of the creation. If we well examine it, we shall not find, I suppose, the motion of dull and senseless matter, any where in the universe, made so little use of, and so wholly thrown away." — "They, who make the soul a thinking being, at this rate, will not make it a much more noble being, than those do, whom they condemn, for allowing it to be nothing but the subtilest parts of matter." *Essay concerning Human Understanding*, b. ii. ch. 1. ss. 12, 13. 15.

[f] l. c. b. ii. ch. 1. s. 14.

[g] Dr. Macnish, l. c. p. 45.

dangers were imaginary, and always threw himself down a precipice near which he dreamt he was standing, and thus destroyed the illusion; or, as Dr. Beattie, when, dreaming himself in danger upon the parapet of a bridge, and reflecting he was not in the habit of such pranks and might therefore be dreaming, determined to awaken himself by pitching over, and did so with success.[h]

Dreams differ much in their absolute vividness, as well as in the impression they make and the degree in which they are remembered.

We sometimes wake in our dream, and soon fall asleep and experience a continuation of it.

I conceive that all the phenomena of dreaming resolve themselves into partial activity of brain, partial not in Gall's view only, who considers that there is activity of one or of a limited number of cerebral organs, but also partial in regard to individual organs, —one portion of an organ being active and another not; and I conceive that the activity of the organ or portion of organ or organs may be of various degrees of intensity. All the phenomena of dreaming may be thus explained: though some, strangely enough, cannot understand how to view dreaming as a disturbed state of *brain* is at all more explanatory than to view them independently of the brain; and call it " making insignificant speech supply the place of analysis," or, " merely a translation of one language to another,"[i] to take into consideration the organ, the disturbance of whose functions actually constitutes dreams.

An idea, being excited, excites another associated with it by the order of previous occurrence, by similarity, or some other of the endless modes of association, exactly as happens in the waking state. But, as our brain is imperfectly and partially active, so that we are not, as in the waking state, intelligent enough to perceive the grossest incongruities and impossibilities, nor possessed of power of volition sufficient to detain an idea and prevent its floating off and being replaced by another associated with it perhaps in the most trifling manner, and this by another and another in endless successive images, thoughts riot on in confusion, not in the order of previous succession, as some assert, but

[h] Dr. Macnish, l. c. p. 108. sq.

[i] *London Review*, No. II. p. 430. *Isis revelata*, vol. ii. p. 120.

more like the cross reading of a newspaper, according to a remark of Dr. Macnish.[k]

> "Fancy,—
> Wild work produces oft, but most in dreams,
> Ill matching words, and deeds long past or late."[l]

A dream sometimes continues rational and consistent till near its end, when it suddenly becomes absurd.[m]

Some have supposed that the diversity and incongruous character of dreams "arises solely from our having no external sensations."[n] This appears to me a very confined view of the state of the mind during dreaming. The want of external sensations is not the only point, nor the chief point; but the want of intelligence and volition, and the intensity of our conceptions. We may have sensations and yet be asleep and dream. We may feel heat applied to our feet and fancy we are in eternal torments: yet should we wake, without any further use of our external senses, without smelling, tasting, hearing, seeing, and without moving, we discover the unreality of our fancy, and, though we should be lying uncovered on the ground in the dark, with no means of knowing by external sense where we are, or how we got where we are, we know for certain that we not in hell, but are satisfied of being still upon earth. In truth we think the most acutely when we have no external sensation. When we wish to meditate, we seek silence, generally shut our eyes, and may become motionless so as to have no touch, and as to tasting and smelling we do not think of such things. We often meditate in bed in the darkness and stillness of night, and forget where we are. While excluding and not aware of any external sensations, we may be most successful in poetical conceptions, and yet do not mistake them for realities. The evident reason of which is the same as of our poetry differing from the wild nonsense of dreams:—we are awake and fully intelligent. Of course, when we are awake, our external senses are in play, give us information, and may correct our thoughts: but, if their impressions may have no relation to our thoughts, and thus afford no correction, and yet we can medidate most philosophically without dreaming, their activity generally cannot be the cause of our not being asleep and dream-

[k] l. c. p. 49.

[l] *Parad. Lost*, B. v.

[m] Hood's *Whims and Oddities*, quoted by Dr. Macnish, l. c. p. 42.

[n] Darwin, *Zoonomia*, vol.i. p. 293.

ing. The very want of external sense is the effect of the sleep of a portion of the brain: and the want of intelligence is another effect; not the effect of the want of external sense.

It is the same with the portion of the brain devoted to emotions, notwithstanding the ideas calculated to excite them are perhaps present. Few or more may be inactive. "Objects, scenes, and circumstances present themselves to the mind, unassociated with those feelings with which they are usually or invariably accompanied in our waking hours. Thus in our dreams we may walk on the brink of a precipice, or see ourselves doomed to immediate destruction by the weapon of a foe or the fury of a tempestuous sea, and yet feel not the slightest emotion of fear, though, during the perfect activity of the brain, we may be naturally disposed to the strong manifestation of this feeling; again, we may see the most extraordinary object or event without surprise, perform the most ruthless crime without compunction, and see what in our waking hours would cause us unmitigated grief, without the smallest feeling of sorrow. Dreams of this kind are more incoherent, and are subject to more rapid transitions than those in which one or more organs of the feelings are also in a state of activity."[o] We might as well ascribe want of emotion to the want of external sense.

Again, we sometimes have great emotion during sleep: sexual desire, terror, rage, &c.[p]; and we sometimes have great intelligence, of which instances have been already given. But the

[o] *Some Remarks on Dreaming, Somnambulism, and other States of partial Activity of the Cerebral Faculties.* Read to the London Phrenological Society, by Professor Wheatstone, and published in the *Lancet,* March 31. 1832, through misprint, as by Mr. Weisten; and Dr. Macnish quotes it as mine, with a compliment to the acuteness of the last sentence. (l. c. p. 76. sq.) But I am happy to say that there is at King's College, as well as at University College, a professor who has for many years been a decided phrenologist and avows his conviction. Excepting this original remark, the paper is professedly nothing more than a translation and illustration of Gall. I am indebted to it for my references to Coleridge, Tartini, and M. Giron de Buzareingues, not to Dr. Macnish, who appears to have taken them from it without acknowledgment, and after all is incorrect, as he puts Cabanis for Franklin, and Condorcet for Condillac.

[p] Porro hominum mentes magnis quæ motibus edunt?
Magna etiam sæpe in somnis faciuntque geruntque.
Reges expugnant, capiuntur, prælia miscent;
Tollunt clamores, quasi si jugulantur ibidem,
Multi depugnant, gemitusque doloribus edunt. *Lucretius.*

intelligence, however acute, is limited : concentrated in one point, without the general intelligence of our waking moments, so that a collateral incongruity or impossibility is not detected.

I believe that excitement of the portions of the brain destined for emotion is more frequently the cause of the train of ideas than those of the intellect; just as the hallucinations of madmen most frequently arise from the morbid state of a feeling, — the idea of being God or an Emperor, for instance, from inordinate pride : and I may mention that Prof. Wheatstone remarked to me in conversation that his observation of the greater incoherency and rapidity of transitions in dreaming, where emotion was not excited, might be extended to insanity. Still, I should say that, if very many passions are excited in either dreaming or insanity, this effect of emotion will be lost and the incoherence be very great. The organs of the feelings may be excited alone in sleep. We often wake under emotion, without knowing why. If it is urged that we may have dreamt unpleasant things, but forgotten them, which may be true, for we may recollect our dream after some lapse of time, I add that, after going to bed under distress of mind, we often wake in the morning feverish and wretched without knowing why, till, after trying to consider the reason, we in a few minutes recollect the real cause of our disquietude. The emotion or unpleasant excitement of an organ of a feeling must have existed during sleep, unaccompanied by images; at least their occurrence is a mere hypothesis.

The excitement may be limited even to portions of organs, or to particular modes of excitement. Just as in paralysis we sometimes find one patient's organ of language so affected that he forgets nouns substantive only, and but some of them, and another forgets one particular language only of two or more that he may have learnt, so in dreaming we may hear or talk one language only of several that we know, or we may see every thing of one colour.

The excitement of the individual part that dreams may of course be of all degrees : the conceptions may be almost too obscure for us to discern them : they may be most vivid : we may surpass our best efforts of the waking state, as happens sometimes in insanity : we may remember things forgotten, and which we have in vain attempted to remember ; nay, we probably sometimes remember in our dreams without ever being aware that what we

dream is the result of memory, and thus have revelations which appear singular, but which are merely revived knowledge, utterly forgotten.[q] Dreaming being only excitement of some portion or portions of the brain while the rest are asleep, the causes of dreaming, no less than their mode of operation, must be analogous to those of excitement in any other organ. These exciting causes will produce their effect, like all other exciting causes, not only according to their own intensity, but according to the predisposition and present degree of excitement of the brain; having, unless powerful, no effect if the brain has no undue irritability or present excitement, and having, though feeble, great effect if the brain is very irritable or already much excited: and, where either of the latter circumstances exists, dreaming will occur without any adventitious cause of excitement. We may dream from an external impression upon any of our nerves or from feelings produced in any internal part: from light being let into the eyes, external heat or cold, titillation, an uncomfortable bed, motion, pain, uneasiness of the digestive organs, &c. We may dream from the brain being excited sympathetically with the condition of any other organ, just as all other organs may sympathise with each other: as the state of the kidney or the brain may produce vomiting, the state of the stomach produce headach, though productive of no uneasy sensation in the stomach itself, so the administration of substances possessed of the power of stimulating the brain in particular, as certain narcotics in doses not sufficient to overpower the organ and cause sleep, may induce dreams. Whatever excites the blood-vessels of the brain will do the same: the ingurgitation of stimulants, blows, great functional excitement, and any cause of an inflammatory state or an approach to it. When the brain is irritable by disease, as in fever, dreaming occurs; and, sleep taking place with difficulty, the delirium of approaching sleep continues so long and sleep is so often interrupted, that nurses tell us that the patient wandered greatly at night. But, independently of its excitement of such a state, the functional excitement of the brain in the waking state may be too great for complete sleep, by not easily subsiding, so that, if not too great to prevent sleep, it may continue sufficiently to prevent the

[q] See a curious instance of the discovery of legal papers by a dream, in Sir Walter Scott's notes to the *Antiquary*.

complete repose of the brain, and may cause dreaming. Like delirium, dreaming may arise from the opposite of stimulation,—from the want of due stimulation, as from want of food, or want of stimuli rendered necessary by habit. In dreaming there will be all degrees and extent of excitement, just beyond perfect repose or sound sleep, and just short of the waking state.

From the great irritability of children, shown by the facility with which they have convulsions and inflammation, they dream much; and their dreams are more frequently frightful than those of adults. Old people, from the lightness of their sleep, also dream much.

From the renewed power and irritability of the brain we dream much more as the period for waking approaches.[r]

The greater the development of a particular part of the brain, and the greater its natural or acquired irritability, the more liable will it than other parts of the brain be to dream; and for the same reason dreams partake of the individual's character, and, as old people remember the events of their early life the best, they dream most of these, while young persons dream of recent things.[s] There are however exceptions to this. The natural character of the insane generally continues in their disease, but sometimes is quite altered: and dreams may occur in which the tone of the feelings may differ from that of the waking state. The dreams of drunkenness and under the influence of narcotics are the most extravagant.[t]

A curious circumstance is the direction given to dreams by the character of the exciting cause. When they arise from uneasy sensations, they are disagreeable; and I may remark that, if the cause of dreams is disagreeable, all the feelings excited will be excited disagreeably, and the images will be disagreeable. Even a strange bed, though soft and warm, may make us dream simply because it is not that to which we have been accustomed. If there is any discomfort, mental or physical, sleep may be interrupted the moment after it has begun by a sudden, and perhaps violent, start, or by a sensation of a blow or push, or of a loud noise:

[r] Lord Brougham contends that we dream only during the "transition into and out of sleep." (l. c. p. 117.) This opinion is disproved by watching persons in sleep and observing them toss about and mutter, evidently dreaming, though their sleep continues.

[s] Dr. Macnish, l. c. p. 82.

[t] Ibid. l. c. p. 95.

and it may not be till after this has occurred more than once that the person settles into sleep. Some always experience this on first losing themselves, and then go to sleep for the night.[u] Aristides dreamt that a bull attacked him but only struck his knee; on waking a small boil was there. Dr. James Gregory, having applied a hot bottle to his feet on going to bed, dreamt that he was walking up Etna and finding the ground insufferably hot. One with a blister on his head, dreamt that he was being scalped by Indians. One in a damp bed, that he was being dragged through a stream. A gouty man, when beginning to feel his pain in his sleep, may dream he is on the rack before inquisitors. The sound of music may excite delightful dreams. M. Giron de Buzareingues made some curious experiments on this point, and directed at pleasure the character of his dreams. In his first experiment, having allowed the back of his head to be uncovered during sleep, he thought he was at a religious ceremony in the open air: the custom of the country in which he lived being to keep the head covered excepting on some rare occurrences, among which was the performance of religious ceremonies. On waking, he felt cold at the back of the neck, as he frequently had when present at the real ceremonies. He repeated the experiment in two days, with the same result. In a third experiment he left his knees uncovered, and dreamt that he was travelling at night in the diligence, and all travellers know, he observes, that it is chiefly at the knees they feel cold when travelling by that conveyance at night.[x]

When sleep has not been profound, and persons have muttered, I have amused myself with speaking to them and getting answers from them. Dr. Beattie mentions a man "in whom any kind of dream could be induced, if his friends, by gently addressing him, afforded the subject matter."[y]

[u] Dr. Macnish, l. c. p. 28.

[x] Dr. Magendie's *Journal de Physiologie*, t. viii.

[y] "*Dissertations Moral and Critical.* London, 1783. 4to. p. 217."

Though the nature of dreaming is evident, some writers are so little advanced as to be ignorant of it, and have no other than the most antiquated notions. Mr. Colquhoun, as we shall see, p. 691. *infrà*, supposes that, in dreaming, the soul is struggling to act without the body! and Lord Brougham, conceiving that the mind acts better the more "the influence of the body is withdrawn," says that dreams throw a strong light upon the "subject, and seem to demonstrate the possible disconnection of mind and matter," and illustrate "the mind's independence of

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The power of volition is exerted in two ways — in dwelling upon feelings or ideas, and in exciting muscular motion. (See *suprà*, p. 346. sq.) While we dwell upon a feeling or idea, association occurs, and the various faculties enable us to judge and invent; we remember, desire, &c., attending to some ideas and feelings, and neglecting others. In dreaming, our faculties judge, remember, invent, in general, very imperfectly; or, if on rare occasions, well, and even admirably, on a single matter, still many of our faculties are in total, partial, or a certain degree of repose, and as soon as our dream turns off to something else, absurdities

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matter and capacity of existence without it." (*A Discourse on Natural Theology*, p. 111.) It is very strange, however, that, when the soul is thus unfettered or half unfettered, and thinks by itself, it thinks so oddly, and works, in the vast majority of cases, so much worse than when it has the full assistance of the brain, that we are accustomed, if a man talks or writes nonsense, to say he is dreaming. Even the soul's consciousness of self often becomes false in dreams; and we feel ourselves "conscious of being, or having been, parties in acting and suffering what not only never did, but never could, take place:" "indeed any dream is more or less, may I not say considerably, a check upon the mind of the waking man," and "when we are taxing recollection for by-gone events, we frequently exclaim, 'Did I really do so and so, or did I only dream it.'" (*Observations on the Discourse of Natural Theology*, by Thomas Wallace, Esq. LL.D. p. 107.)

Locke, who argued well for us materialists, says, "How extravagant and incoherent for the most part they are; how little conformable to the perfection and order of a rational being, those who are acquainted with dreams need not be told. This I would willingly be satisfied in, whether the soul when it thinks thus apart, and as it were separate from the body, acts less rationally than when conjointly with it, or no. If its separate thoughts be less rational, then these men must say, that the soul owes its perfection of rational thinking to the body; if it does not, it is wonder that our dreams should be for the most part so frivolous and irrational; and that the soul should retain none of its more rational soliloquies and meditations." (l. c. b. ii. ch. i. s. 16.)

Democritus and Lucretius account for dreams by fancying that the forms or spectres of corporeal things, constantly emitted from them and floating about, assault the soul in sleep: and Baxter, by fancying that spiritual beings amuse or seriously busy themselves in making our souls active in sleep: and I think they had as much reason on their side as Lord Brougham and Mr. Colquhoun.

commence: nay, coherency, after continuing a long while, often terminates in an absurdity on the same subject. The power of volition, whether over our feelings and ideas or muscles, in sound sleep can be but moderately exerted; but its diminution has endless degrees. We may have little or no command over our thoughts, or we may have much, as when we reason, calculate, or compose well. We have all shades of amount of power over our muscles: we breathe, cough, move our head, limbs, and even our trunk, more or less, in ordinary sleep; people forcibly roused frequently get out of bed and begin dressing before they know where they are or what they are about; and, when overcome with sleep in the midst of forced exertion, will continue standing or walking or even moving their fingers at their work. Sometimes we will, in vain, as when awake. When awake, we often make great efforts in vain to detain particular ideas and understand or produce, but find we cannot fix our attention to the point, or, if we do, that our cerebral organs are incapable of work; sometimes we will motion without effect. So in sleep, not only is our will generally feeble, but sometimes strong yet unobeyed. We strive in vain to detain thoughts, or, if we succeed, still certain faculties prove powerless. We may will much exertion strenuously, but the part of the nervous system connected with the central extremities of the voluntary nerves is incapable of being stimulated by that which is endowed with mental power. In that imperfect sleep called night-mare, we will violently in vain, but cannot move a muscle, nor utter a cry. Persons believe that, if they can but move or even cry out, they shall recover themselves, mistaking effect for cause: they move and cry out the moment they have recovered.

The phenomena of partial sleep are seen more remarkably in the state called somnambulism, or sleep-walking, than in common dreaming. The term sleep-waking, or somno-vigilium, has been proposed, and is very appropriate, because in this state patients may not walk, or may even be unable to walk. The individual is capable of no impression from his external senses, or from one or some of them only, and, if capable, either perfectly or in

[z] Dr. Darwin (*Zoonomia*, vol. i. sect. 18. p. 286.), and after him Prof. Dugald Stewart, contended that, in sleep, volition was suspended. Dr. T. Brown refuted them in his *Observations on the Zoonomia.*

various degrees of imperfection; some of his intellectual faculties are highly active, and this in various degrees, while others are in complete torpidity; and the various inclinations and emotions may be all inactive or one or more active in various degrees: volition may be exerted over the muscles so that the person shall talk, or walk, and execute various movements, or shall dwell upon ideas at pleasure, and reason and compose, without any general intelligence, so as to be in reality still asleep. Just as occasionally in insanity and in ordinary dreams, an intellectual faculty is sometimes heightened; and sometimes muscular strength, or more properly the force of volition over the muscles. Generally the whole is forgotten: sometimes remembered; sometimes remembered and mistaken for reality; and sometimes remembered only when the same state returns. When persons use their muscles, there must be that internal feeling which accompanies all muscular exertion (p. 527.), — there must be the feeling of weight and resistance. I saw the sleep-waking condition strikingly exhibited lately in a patient of mine in University College Hospital, — a girl, sixteen years of age, destitute of the sense of smell as long as she could remember, subject to pain of her vertex, and, like a sister, epileptic, though very intelligent, very facetious, and of excellent behaviour. After the Baron Dupotet, passing the ends of his fingers up and down before her, had sent her to sleep, on many occasions, for a few minutes at a time, she was observed one day suddenly to talk unconnectedly and move her arms and hands about, though incapable of hearing, seeing, or feeling. She lay in bed or sat, with her eyes open, saying a great number of things, such as she might say when awake, told stories, and with great expression of voice, features, and manner, mimicked the voices and conversation of many fellow-patients accurately, and mimicked the manipulations of Baron Dupotet; yet she saw nobody, could not be roused by hallooing in her ear, and bore the sharpest pinches with indifference. She was cross, expressed displeasure at having before been magnetised, said she would not be made a fool of, complained of different things, shook her head, moving it forwards and frowning, and saying, "You dirty beast." Her hands were very cold in such attacks, and her whole surface pale. She would suddenly come out of this state, stare about like a person waking, rub her eyes, become still, smile, and be completely herself without

the least knowledge of what she had been doing, and feel quite ashamed and beg pardon, when informed that she had said we made a fool of her. After some hours, or days, the attack would return. But, before she remained permanently awake, shesome times fell back repeatedly into the sleep-waking: and nothing could be more striking than to see her eyes suddenly fixed unconsciously, and then all the phenomena of perfect external insensibility and talking begin again in less than a minute: and, in a few minutes, to observe her become suddenly still, look wild or fall fast asleep for an instant, rub her eyes, be sentient of every thing around her, smile, and in short in less than a minute be wide awake, without any knowledge of the state in which she had just been. As she could not be awakened by the strongest agency applied to her external senses, I resolved to try the effect of producing an internal sensation, and heightening her volition over her voluntary muscles. I took her off the bed, and found she could not stand. Two of us supported her erect, and lessened the support now and then, so that she might feel she was falling. Her knees bent, and she would have fallen, had we not held her up. This was repeated a few times, till at last she seemed to feel the ground a little with her feet, and, when we lessened our support, her knees bent less: at length she stood pretty well. Then I forced her on, and, though her legs at first dragged, she at last feebly attempted stepping, soon she walked, and, when she walked firmly, being led on quickly by one of us on each side, she suddenly awoke. This was all the work of not five minutes. I presently laid her down on the bed, and she in a minute relapsed into her old condition: I raised and walked her again, and she was instantly restored; and remained without any return for a week. I did not afterwards succeed in this way. When the affection returned it was not so marked. She had some power of perceiving persons, and hearing and feeling, so that she gave a certain amount of answer and expressed some uneasiness on being pinched. After a few days such attacks ceased, but she fell into the delirium only of the state, — ecstatic delirium: having the full use of her external senses, her volition over her muscles, knowing where she was, and active in all her intellectual faculties and feelings, saying she felt as if her brain was coming out and was too big for her head, and begging me to cut her head off; in short, being wide awake, but wandering unconnectedly from one subject

to another, dejected, saying innocent, but absurd, rude, though often witty and droll, things, which showed her feelings to be disturbed, incoherent, and mimicking admirably, whistling and singing well; and picking paper or linen to pieces: at length in her attacks she occasionally swore, and was amorous. After remaining in this condition for a few days, she suddenly by mesmeric manipulations one evening became herself completely; still complaining of pain at the top of her head, which she had suffered from for many months and for which I had bled her repeatedly. She afterwards suddenly fell into this delirium again several times, and, after continuing in it some hours or days, would by mesmeric manipulations in two or three seconds become completely herself and remain so for some hours or days. To observe her picking paper or linen to pieces, talking incoherently, now whistling aloud, now singing in the ward, cross, miserable, rude, dancing about, unable to look steadily for many seconds, her eyes converging from parallelism, her countenance pale, and expressive now of insanity, now of fatuity; and then in two or three seconds to see her completely herself, smiling, perfectly rational, amiable, well behaved, with an expression of great intelligence, was one of the most extraordinary changes I ever witnessed; — to see the functions of the brain in many points nearly suspended, in many over excited, and in many wrong, — the organ altogether oppressed and deranged, and then righting itself and performing all its functions properly in an instant, made an impression upon me never to be effaced. When not in an attack, she forgot every thing that had occurred in her attacks: but, when in them, she recollected the occurrences of preceding attacks. In the delirium her hands were not always cold as in the sleep-waking. The pulse appeared hardly affected.

I will relate a number of examples of sleep-waking to show the various amount and extent of activity in this condition.

This first is very similar to that of my own patient, but *sleep-walking* was added in one stage of the paroxysm.

" At Berlin," says Gall, " a young man, sixteen years old, had extraordinary attacks from time to time. He was agitated in his bed without consciousness; his movements and gestures showed a great activity of many internal organs; whatever was done to him, he did not perceive it; at length he jumped out of bed, and walked hastily in the apartment: his eyes were then

fixed and open. I placed different obstacles in his way, which he removed with his hand, or carefully avoided; then he threw himself suddenly on his bed, was agitated there some time, and at length awoke and sat up, very much astonished at the number of curious persons who were about him."

Here was a certain amount of *sight* and *touch*, and *sense of resistance and weight;* all was *forgotten;* the changes were *sudden.*

" M. Joseph de Roggenbach, at Friburg in Brisgau," continues Gall, " told me, in the presence of many witnesses, that he had been a somnambulist from his infancy. In this state his tutor had frequently made him read; made him look for places on the map, and he found them more readily than when awake; his eyes were always open and fixed; he did not move them, but turned his whole head. Many times they held him, but he felt the restraint, endeavoured to liberate himself, but did not wake. Sometimes he said he should wake if they led him into the garden, and *this always happened.*"

Here was a certain amount of *sight, touch,* and feeling of *resistance* and *weight;* an *increase of one mental power;* and a certain *power of prediction;* he moved, not his eyes, but his *whole head.*

" I knew also the history of a miller, who, dreaming and with his eyes open, would go into his mill, enter upon his usual daily occupation, return to bed by the side of his wife, without remembering in the morning any thing he had done in the night."[a]

Here was a certain degree of *sight,* and feeling of *resistance* and *weight;* and all was *forgotten.*

M. Martinet speaks of a saddler accustomed to rise in his sleep and work at his trade[b]: and Professor Upham of an American farmer who rose in his sleep, went to his barn, and threshed out five bushels of rye in the dark, separating the grain from the straw with great exactness.[c]

These are examples of sleep-walking.

The following are examples of sleep-talking, or sleep-talking and sleep-walking:—

" Dr. Blacklock, the blind poet, on one occasion rose from his bed, to which he had retired at an early hour, came into the room where his family were assembled, conversed with them, and

[a] ll. cc. 4to. vol. ii. p. 456. sqq.; 8vo. t. ii. p. 510. sqq.

[b] *Bibliothèque Médicale.* [c] *Isis revelata,* vol. i. p. 313. sq.

afterwards entertained them with a pleasant song, without any of them suspecting he was asleep, and without his retaining after he awoke, the least recollection of what he had done."

"Dr. Haycock, Professor of Medicine at Oxford, would deliver a good sermon in his sleep; nor could all the pinching and pulling of his friends prevent him." [d]

Horstius mentions a young nobleman who was observed by his brother to rise in his sleep, put on his cloak, open the casement, mount by a pulley to the roof of the citadel of Brenstein where he was, tear a magpie's nest to pieces, wrap the young ones up in his cloak, return to his room, place the cloak with the birds in it near him, and go to bed. In the morning he told the adventure as a dream, and was astonished when shown the magpies in his cloak, and led to the roof and shown the remains of the nest.

"An American lady, now, we believe, alive, preached during her sleep, performing regularly every part of the Presbyterian service, from the psalm to the blessing. This lady was the daughter of respectable and even wealthy parents: she fell into bad health, and under its influence, she disturbed and amazed her family by her nocturnal eloquence. Her unhappy parents, though at first surprised, and perhaps flattered by the exhibition in their family of so extraordinary a gift, were at last convinced that it was the result of disease; and, in the expectation that their daughter might derive benefit from change of scene, as well as from medical skill, they made a tour with her of some length, and visited New York and some other of the great cities of the Union. We know individuals who have heard her preach during the night in steam boats; and it was customary, at tea parties in New York (in the houses of medical practitioners), to put the lady into bed in a room adjacent to the drawing-room, in order that the dilettanti might witness so extraordinary a phenomenon. We have been told by ear-witnesses that her sermons, though they had the appearance of connected discourses, consisted chiefly of texts of Scripture strung together. It is strongly impressed upon our memory that some of her sermons were published in America." [e]

"A lady subject to spectral illusions would not only talk in

[d] Dr. Macnish, l. c. 182.

[e] *Fraser's Magazine.*

her sleep with great fluency, and repeat great portions of poetry, especially when unwell, but even cap verses for half an hour at a time, never failing to quote lines beginning with the final letter of the preceding, till her memory was exhausted."[f]

I will now give instances of sleep-floating and sleep-swimming.

Dr. Franklin says, "I went out to bathe in Martin's salt water hot bath, in Southampton, and, floating on my back, fell asleep, and slept nearly an hour, by my watch, without sinking or turning, — a thing I never did before, and should hardly have thought possible." This showed only the completeness of his repose: but Dr. Macnish quotes a case of actual swimming in sleep on the coast of Ireland. "About two o'clock in the morning, the watchmen on the revenue quay were much surprised at descrying a man disporting himself in the water, about 100 yards from the shore. Information having been given to the revenue boat's crew, they pushed off, and succeeded in picking him up, but strange to say, he had no idea of his perilous situation, and it was with the utmost difficulty they could persuade him he was not still in bed. But the most singular part of this novel adventure, and which was afterwards ascertained, was that the man had left his house at twelve o'clock that night, and walked through a difficult and, to him, dangerous road, a distance of nearly two miles, and had actually swum one mile and a half, when he was fortunately discovered and picked up." He then adds a case of fishing. "Not very long ago a boy was seen fishing off Brest up to the middle in water. On coming up to him, he was found to be fast asleep."

The information given us with respect to these cases extends no further, and we cannot tell the state of the eyes.

Dr. Pritchard mentions an individual who, having "been in the habit of frequenting a public promenade where he used to meet his acquaintances, was seen to rise from his bed at night and walk in his shirt along the same path, which extended a mile on the brow of a hill, stopping very frequently and greeting different individuals whom he had been accustomed to see in the same place."[g]

[f] *Edinburgh Journal of Science.* See Dr. Macnish.

[g] *A Treatise on Insanity and other Disorders respecting the Mind.* By James Cowles Pritchard, M.D. F.R.S. 1835. p. 407.

Vision might here have existed sufficiently to show him his way, though the state of his brain suggested to him imaginary forms; or he might have made his greetings by habit, without fancying he saw individuals.

" A female servant in the town of Chelmsford, surprised the family at four o'clock one morning, by walking down a flight of stairs in her sleep, and rapping at the bed-room door of her master, who inquired what she wanted; when, in her usual tone of voice, she requested some cotton, saying that she had torn her gown, but hoped that her mistress would forgive her: at the same time bursting into tears. Her fellow servant, with whom she had been conversing for some time, observed her get out of bed, and quickly followed her, but not before she had related this pitiful story. She then returned to her room, and, a light having been procured, she was found groping to find her cotton box. Another person went to her, when, perceiving a difference in the voice, she called out, 'That is a different voice — that is my mistress;' which was not the case, — thus clearly showing that she did not see the object before her, although her eyes were wide open. Upon inquiry as to what was the matter, she only said that she wanted some cotton, but that her fellow servant had been to her master and mistress making a fuss about it. It was now thought prudent that she should be allowed to remain quiet for some short time, and she was persuaded to lie down with her fellow servant that she might then awake in her accustomed manner. This failing in effect, her mistress went up to her room, and rather angrily desired her to get up and go to her work, as it was now six o'clock: this she refused, telling her mistress that if she did not please her she might look out for another servant, at the same time saying she would not rise at two o'clock, pointing to the window, to injure her health for any one. For the sake of the joke, she was told to pack up her things, and start off immediately, but to this she made no reply. She rebuked her fellow servant for not remaining longer in bed, and shortly after this became quiet. She was afterwards shaken violently, and awoke. She then rose, and seeing the cotton box disturbed, demanded to know why it had been meddled with, not knowing that she alone was the cause of it. In the course of the day several questions were put to her in order to try her recollection, but the real fact of her walking was not

made known to her; and she is still quite unconscious of what has transpired." [h]

Here sight was suspended, but *hearing perfect*, as well as *touch* and the *feeling of weight and resistance;* all was *forgotten;* she was *roused* by shaking, and with *impunity*.

A lad named George David, sixteen years old, in the service of Mr. Hewson, a "butcher in Bridge Road, Lambeth, at about twenty minutes past nine, bent forward in his chair, and rested his forehead on his hands, and in ten minutes started up, went for his whip, put on one spur, and went thence into the stable; not finding his own saddle in the proper place, he returned to the house and asked for it. Being asked what he wanted with it, he replied, to go his rounds. He returned to the stable, got on the horse without the saddle, and was proceeding to leave the stable: it was with much difficulty and force that Mr. Hewson, junior, assisted by the other lad, could remove him from the horse: his strength was great, and it was with difficulty that he was brought in doors."—"The lad considered himself as stopped at the turnpike gate, and took sixpence out of his pocket to be changed; and holding out his hand for the change, the sixpence was returned to him. He immediately observed, 'None of your nonsense, that is the sixpence again; give me my change.' When twopence halfpenny was given to him, he counted it over, and said, 'None of your gammon, that is not right; I want a penny more,' making the threepence halfpenny, which was the proper change. He then said, 'Give me my castor,' (meaning his hat) which slang term he had been in the habit of using, and then began to whip and spur to get his horse on. His pulse was at this time at 136, full and hard; no change of countenance could be observed, nor any spasmodic affection of the muscles, the eyes remaining close the whole of the time."—"During the time of bleeding, Mr. Hewson related a circumstance of a Mr. Harris, optician in Holborn, whose son, some years since, walked out on the parapet of the house in his sleep. The boy joined the conversation, and observed, 'He lived at the corner of Brownlow Street.' After the arm was tied up he unlaced one boot, and said he would go to bed. In three minutes from this time, he awoke, got up, and

[h] Dr. Macnish, 164. sqq.

asked what was the matter (having been then one hour in the trance), not having the slightest recollection of any thing that had passed, and wondered at his arm being tied up, and at the blood, &c."[i]

Here *sight*, *hearing*, and *touch*, as well as the sense of *weight* and *resistance*, were active; and all was *forgotten*.

According to the newspapers, a year or two ago, John Green, a plasterer, accused Mary Spencer at the Town Hall, Southwark, before Alderman Thorp, of stealing from him a pair of trowsers which he was carrying home at ten o'clock at night, through High Street, in the Borough, fast asleep.

" He deposed that, after finishing his work, he went to see some friends at Pimlico, and was accosted by a female; he had at the time a bundle under his arm. He knew no more of what transpired until between one and two o'clock on Sunday morning.

" *Alderman Thorp.* What! were you so drunk that you cannot tell what happened?

" *John Green* (with great simplicity). I was not drunk, your worship; I was fast asleep. (Laughter.)

" *Alderman Thorp*" (with greater simplicity, though officially one of those who are presumed competent to determine who are the fittest persons to be physicians and surgeons and teachers in St. Thomas's and other hospitals, and who generally allow themselves to be led by one whom they have made treasurer and consider fit to guide them in their judgment, having himself in most instances already retired from business). " You cannot be serious. I never heard of such a thing, as a man walking through a crowded thoroughfare, like the Borough High Street, without being disturbed.

" *John Green.* What I have stated, your worship, is true; I am unfortunately too frequently afflicted with fits of somnambulism; and, for greater security from robbers, I always make what articles I carry fast to my arm, so that if any one attempt to snatch it from me it would awaken me.

" *Alderman Thorp.* But how do you know the prisoner is the party who accosted you in the Borough? If you were asleep, you could not see her.

[i] *Lancet*, vol. i.

"*John Green.* Strange as it may appear, although I have not the power to arouse myself when in such a state of excessive lethargy, yet I can retain the sound of persons' voices in my mind, and, from the voice of the prisoner, I have not the least doubt she is the party.

"*Alderman Thorp.* How do you account for the lapse of time, from being accosted by the prisoner up to the time you discovered your loss?

"*John Green.* I am in the habit of walking for hours in my sleep, and if an attempt had been made to forcibly take the bundle from my arm, it would have aroused me; my handkerchief was cut, and thus the bundle was easily taken away.

"*Alderman Thorp.* I never heard such a case before; was the bundle found?

"Acting Inspector M'Craw, division M., answered in the affirmative, and added, that what the complainant had stated about walking the streets and roads was true: he had made inquiries, and found it to be the fact: it was well known to the police.

"Watt, Police constable 163., division M., deposed, that the complainant came to the station-house between one and two o'clock on Sunday morning, and made precisely the same statement he had made before the Alderman. The Inspector thought the tale savoured of the marvellous, and told witness to accompany him (complainant) in search of the property; and on arriving at a house in Kent Street, Borough, he said he thought the bundle was there. He knocked at the door, which was opened, and by the door of a room wherein the prisoner was sleeping, the property was found. The moment she spoke, he said the prisoner was the person who stopped him in the Borough. Witness took the prisoner to the station-house.

"The prosecutor here pointed out the way in which the bundle must have been taken away, and showed the Alderman the rent handkerchief.

"Mr. Edwards for the prisoner contended that no jury would convict upon the evidence of a sleep-walker, in prosecution against a street-walker. The prisoner laid no claim to the bundle; and as the complainant had sworn it was his property, the police would give it up to him.

"*Alderman Thorp* said it was so strange a case that he hardly

knew how to act; he should, however, under the doubtful circumstance as to identity, give the prisoner the benefit of it, and discharge her. The bundle was given up to the complainant.

"A gentleman, who was in attendance, said he had known the complainant many years, and it was not an uncommon thing for him to be seized with that unhappy affliction while at work on the scaffold, and yet he had never met with an accident, and while in that state, would answer questions put to him as though he was awake." [k]

Hearing was retained, as well as the sense of *weight* and *resistance*, and possibly *sight* to a certain degree; the attack came on suddenly, in the waking state; so that the case, like that of my patient, was one of partial sleep in the waking state,—ecstacy as it is termed, and not of partial excitement during sleep.

An Italian nobleman, named Augustin Forari, was subject to sleep-waking, and on one occasion watched by a Signor Vigneul Marville, who gave the following account:—

"One evening towards the end of October, we played at various games after dinner: Signor Augustin took a part in them along with the rest of the company and afterwards retired to repose. At eleven o'clock his servant told us that his master would walk that night, and that we might go and watch him. I examined him some time after with a candle in my hand; he was lying upon his back, and sleeping with open, staring, eyes. We were told that this was a sure sign that he would walk in his sleep. I felt his hands and found them extremely cold, and his pulse beat so slowly that his blood appeared not to circulate. We played at backgammon until the spectacle began. It was about midnight, when Signor Augustin drew aside the bed-curtains with violence, arose, and put on his clothes. I went up to him and held the light under his eyes. He took no notice of it, although his eyes were open and staring. Before he put on his hat, he fastened on his sword-belt, which hung on the bed-post: the sword had been removed. He then went in and out of several rooms, approached the fire, warmed himself in an armchair, and went thence into a closet where was his wardrobe. He sought something in it, put all the things into disorder, and having set them right again, locked the door, and put the key

[k] *Isis revelata.*

into his pocket. He went to the door of the chamber, opened it, and stepped out on the staircase. When he came below, one of us made a noise by accident: he appeared frightened, and hastened his steps. His servant desired us to move softly, and not to speak, or he would become out of his mind; and sometimes he ran as if he were pursued, if the least noise was made by those standing around him. He went into a large court and to the stable, stroked his horse, bridled it, and looked for the saddle to put on it. As he did not find it in the accustomed place, he appeared confused. He then mounted his horse and galloped to the house door. He found this shut; dismounted, and knocked several times at the door with a stone which he had picked up. After many unsuccessful efforts he remounted, and led his horse to the watering place, which was at the other end of the court, let it drink, tied it to a post, and went quietly to the house. Upon hearing a noise which the servants made in the kitchen, he listened attentively, went to the door, and held his ear to the keyhole. After some time he went to the other side, and into a parlour in which was a billiard table. He walked round it several times, and acted the motions of a player. He then went to a harpsichord on which he was accustomed to practise, and played a few irregular airs. After having moved about for two hours, he went to his room, and threw himself on his bed in his clothes, and we found him in them the next morning, for after his attacks, he always slept eight or ten hours. The servants declared they could put an end to the paroxysm only either by tickling his soles, or blowing a trumpet in his ear."[1]

Here, *hearing*, *touch*, the sense of *weight* and *resistance* were active, and probably *sight* to some degree; he was *roused* with *impunity*.

Drs. Righellini and Pigatti describe, from their own observation, the sleep-waking of a man servant named Negretti, twenty-four years of age, who, from his eleventh year, had experienced attacks of the disease in March, not extending beyond April. March 16. 1740, after going to sleep on a bench in the kitchen, he first began to talk, then walked about, went to the dining-room and spread a table for dinner, and placed him-

[1] L. A. Muratori, *della forza della Fantasia Umana*. Venezia. 1766. Dr. Pritchard, l. c.

self behind a chair with a plate in his hand, as if waiting on his master, the Marquis Luigi Sale. After waiting till he thought his master had dined, he cleared away, and put all the things into a basket, which he locked up in a cupboard. He afterwards warmed a bed, locked up the house, and prepared for rest. Being then awakened, and asked if he remembered what he had been doing, he answered, 'No.' Often, however, he did remember. On the 18th of the same month, he went through the same process, but, instead of going to bed, went into the kitchen and sat down to supper. Dr. Righellini, with many others, were very curious to see him eat. At once recollecting himself, the man said, 'How can I so forget? to-day is Friday, and I must not dine.' He then locked up every thing and went to bed. If water was thrown in his face or his eyes were forcibly opened, he would awake, but remained some time faint and stupid. His eyes were firmly closed in the paroxysm, and he took no notice of a candle placed close to them. Sometimes he went against the wall, and even hurt himself severely. If any body pushed him, he got out of the way, and moved his arms rapidly on every side: and, if in a place with which he was not well acquainted, he felt all the objects around with his hand, and showed much inaccuracy; but, in places familiar to him, he was not confused and went through his business well. After Dr. Pigatti had shut a door through which he had just passed, he struck himself against it on returning. Sometimes he carried a candle about, but, on a bottle being substituted, he carried it about as if it were a candle. Dr. Pigatti was certain he could not see. Once in his sleep he said he must go and hold a light to his master in his coach. Dr. Righellini followed him closely, and found that he stood at all the corners of the streets with his torch not lighted, waiting a while in order that the coach which he fancied was following might pass when the light was required. On one occasion he ate several cakes and some salad for which he had just asked the cook. He then went with a lighted candle into the cellar and drew wine, which he drank. He would carry a tray with wine-glasses and knives, and turn it obliquely, to avoid an accident, on passing through a narrow doorway. Dr. Pigatti once substituted some strongly seasoned cabbage for a salad which he had prepared and had sit down to eat: he ate the cabbage, and then some pudding which was substituted for it, without

perceiving the difference. At another time, having asked for wine, he drank water which was given to him; and sniffed ground coffee after asking for snuff. [m]

The state of *taste* and *smell* was here inquired into, and found inactive: *touch* and the sense of *weight* and *resistance* were active; *sight* inactive; and the actions were habitual.

Dr. Francesco Soave relates the case of Castelli, the pupil of an Italian apothecary. The youth was found asleep one night, translating Italian into French, and looking out the words in a dictionary. They put out his candle, when he, finding himself in the dark, began to grope for it, and went to light it at the kitchen fire, though other candles were alight in the room At other times he had gone down to the shop and weighed out medicines, and talked to supposed customers. "When any one conversed with him on a subject on which his mind was bent, he gave rational answers. He had been reading Macquer's Chemistry, and somebody altered his marks. This puzzled him; and he said, 'Bel piacere di togliermi i segni.' He found his place and read aloud, but his voice growing fainter, his master told him to raise it, which he did. Yet he perceived none of the persons standing round him; and though he heard," says Dr. Soave, "any conversation which was in conformity with the train of his ideas, he heard nothing of the discourse which these persons held on other subjects. His eyes seemed to be very sensible to objects relating to his thoughts, but appeared to have no life in them; and so fixed were they, that, when he read, he was observed not to move his eyes but (like M. Roggenbach, p. 631. *suprà*) his whole head from one side of the page to the other." [n]

Here was most decided *sight*, though the existence of it was so partial, and his mind could attend in so limited a way that the presence of other candles was not noticed, and he went to the kitchen for a light: *hearing* was active; of course the sense of *weight* and *resistance*, and *touch*. *Volition over the muscles* was rather weak, as his voice grew fainter while he read, and he did not exert the muscles of his eyes, but *moved his whole head.*

Still more, however, has been done in sleep-waking.

[m] Muratori, l. c.

[n] *Riflessioni sopra il Somnambolismo:* di Francesco Soave.

"In 1686, Lord Culpepper's brother was indicted at the Old Bailey for shooting one of the guards and his horse. He pleaded somnambulism, and was acquitted, on producing ample evidence of the extraordinary things he did in his sleep. There is a somewhat similar story of a French gentleman, who rose in his sleep, crossed the Seine, fought a duel, and killed his antagonist, without recollecting any of the circumstances when awake." [o]

The next, as well as the cases mentioned at p. 633. illustrates the occasional great acuteness of sleep-wakers. "A young man named Johns, who works at Cardrew, near Redruth, being asleep in the sumpter-house of that mine, was observed by two boys to rise and walk to the door, against which he leaned: shortly after, quitting this position, he walked to the engine shaft, and safely descended to the depth of twenty fathoms, where he was found by his comrades soon after, with his back resting on the ladder. They called to him to apprise him of the perilous situation in which he was, but he did not hear them, and they were obliged to shake him roughly till he awoke, when he appeared totally at a loss to account for his being so situated." [p]

In the following cases a partial increase of mental power took place, as is sometimes noticed in insanity and common dreams:—

"A story is told of a boy who dreamed that he got out of bed, and ascended to the summit of an enormous rock, where he found an eagle's nest, which he brought away with him and placed under his bed. Now the whole of these events actually took place; and what he conceived, on awaking, to be a mere vision, was found to have had an actual existence, by the nest being found in the precise spot where he imagined he had put it, and by the evidence of spectators who beheld his perilous adventure. The precipice which he ascended was of a nature that must have baffled the most expert mountaineer, and such, as at other times he could not have scaled." [q]

Gassendi tells of a man who often rose and dressed in his sleep, went into a cellar and drew wine, appearing to see in the dark as well as in the day; but, when he awoke either in the cellar or street, was obliged to grope his way back to bed. He often thought there was not light enough, and that he had risen

[o] *Isis revelata*, vol. i. p. 316.

[p] Dr. Macnish, p. 166.

[q] Dr. Macnish, l. c. p. 170.

too early, and therefore struck a light. He tells of another who passed on stilts "over a torrent asleep one night, and on awaking was afraid to return before daylight, and before the water had subsided." [r]

The intellectual achievements of Coleridge and others during ordinary dreaming are as striking as any thing of the kind to my knowledge recorded of sleep-waking.

An increase of muscular strength has sometimes, as in insanity, been noticed. One Sunday, Mr. Dubrie, a musician at Bath, attempted in vain to open a window that happened to be nailed down in his bed-room. At night he rose in his sleep, and made the attempt successfully, but threw himself out and broke his leg. [s]

The increase of mental power, in respect of determinate muscular movement, is shown in that unusual variety of chorea called leaping ague, in fits of which persons wide awake involuntarily dance admirably who had never learnt, performing the most difficult steps and exhibiting exquisite grace, rapidly execute all kinds of difficult movements, and run violently in the most dangerous situations without mischief. [t] Lord Monboddo describes a sleep-walking girl in Scotland, about sixteen years of age, who, in her fits, which began with drowsiness ending "in sleep, or what had the appearance of sleep, for her eyes were close shut," would leap upon stools and tables with surprising agility, and "run with great violence and much faster than she could do when well, but always with a certain destination to some one place in the neighbourhood, and to which place she often said, when she found the fit coming upon her, that she was to go; and after she had gone to the place of her destination, if she did not there awake, she came back in the same direction, though she did not always keep the high road, but frequently went a nearer way across the fields; and though her road, for this reason, was often very rough, she never fell, notwithstanding the violence with which she ran. But all the while she ran, her eyes were quite shut, as her brother attests, who often ran with her to take care of her, and who, though he was much stronger, older, and cleverer than she, was hardly able to keep up with her. When

[r] Dr. Pritchard, l. c. p. 434. sq. [s] Dr. Macnish, 171.

[t] See, for instance, *Med. Chir. Trans.* vol. v. and vii.

she told, before the fit came on, to what place she was to run, she said she dreamt the night before that she was to run to that place; and though they sometimes dissuaded her from going to a particular place, as to my house, for example, where they said the dogs would bite her, she said she would go that way and no other. When she awoke, and came out of her delirium, she found herself extremely weak, but soon recovered her strength, and was nothing the worse for it, but, on the contrary, was much the worse from being restrained from running. When she awoke and came to herself, she had not the least remembrance of what had passed while she was asleep. Sometimes she would run upon the top of the earthen fence which surrounded her father's little garden; and though the fence was of an irregular figure, and very narrow at top, yet she never fell from it, nor from the top of the house, upon which she would sometimes get, by the assistance of this fence, though her eyes were then likewise shut." Once, in a fit, she had a violent desire to drink of water from a particular well, and on their giving her other water, "she would not let it come near her, but rejected it with great aversion; but when they brought her water from this well, she drank it greedily, her eyes being all the while shut. Before her last fit came upon her, she said that she had just three leaps to make, and she would neither leap nor run more. And accordingly, having fallen asleep as usual, she leaped up upon the stone at the back of the chimney, and down again; and having done this three times, she kept her word, and never leaped or ran more. She is now in perfect health." [u]

In a recent American case of somnambulism, to which I shall presently refer, the patient, with her eyes closed, "sometimes engaged in her usual occupations, and then her motions were remarkably quick and impetuous; she moved with astonishing rapidity, and accomplished whatever she attempted with a celerity of which she was utterly incapable in her waking state."

In another, though the patient, in her fits of sleep, while her eyes were open and she was talking to her acquaintance, making ironical applications to them under feigned names, was perfectly insensible to pricking with needles, to wrenching her fingers, to brandy and hartshorn put into her eyes and mouth, Spanish snuff in

[u] *Ancient Metaphysics.*

her nostrils, a candle held so near her eyes as to burn the lashes, the noise of a loud voice in her ears or of a stone thrown against the back of her bed, she would nevertheless spring out of bed, and keep "the middle way between the bedsteads as well as when awake, and never come against them, turning dexterously round between the bedsteads and a concealed closet without even groping the way or touching the objects; and after turning round, she returned to her bed, covered herself with the clothes, and again became as stiff as at the commencement. She then awoke, as if from a profound sleep, and when she perceived, from the appearance of the bystanders, that she must have had her fits again, she wept the whole day for shame, and never knew what had happened to her during the paroxysm." [x]

In general patients are not easily awakened. Sometimes they are. Dr. Pritchard knew a man, who was accustomed to attend a weekly market, rise from his bed, saddle his horse, and proceed as far as the turnpike, which, being shut, awakened him. I have already given other examples. Although the persons mentioned were awakened with impunity, immediate death has occasionally been the consequence. Dr. Macnish mentions a young lady subject to sleep-walking, whose door one night was not, as usual, secured, so that she walked out into the garden; and there she was awakened by some of the family who followed her. But the shock was such that she almost instantly expired. [y]

One evening, about twelve or eighteen months ago, at Dresden, a young lady was observed walking upon the top of a house. The alarm was given, and a considerable concourse assembled. Every precaution was taken to prevent her from receiving injury in case of falling: the street was covered with beds, mattresses, &c. Meanwhile, the young lady, apparently unconscious of danger, came forward to the edge of the roof, smiling and bowing to the multitude below, and occasionally arranging her hair and her dress. After this scene had continued for some time, and the spectators were in the utmost anxiety for her safety, she at length proceeded towards the window of a room from which she had come. In their alarm, some of her family had placed a light in it, which the somnambulist perceived, and in

[x] M. Sauvage de la Croix. *Isis revelata*, vol. i. p. 33f

[y] l. c. p. 173.

consequence suddenly awoke, fell to the ground, and was killed on the spot.[z]

The curious occasional circumstance of our not remembering the points of a dream till dreaming of the same things again, has been strikingly noticed in sleep-waking.

Ritter[a] describes a somnambulist boy, who, on waking, recollected nothing that occurred in his sleep, but could talk of other matters. On falling asleep again, he could resume his discourse just where it had been interrupted by his waking; on waking again, he would know nothing that had transpired in his sleep, but recollect what had been said to him last when awake; and thus, says the simple reporter, it appeared as if he had two souls, one for the state of sleep, and the other for the period when he was awake. My patient recollected the occurrences of her paroxysms of extatic delirium in her paroxysms only. (*Suprà*, p. 630.)

Even in the mixed stupefaction and excitement of intoxication the same phenomenon has presented itself. "Dr. Abel informed me," says Mr. Combe, "of an Irish porter to a warehouse, who forgot, when sober, what he had done when drunk: but, being drunk, again recollected the transactions of his former state of intoxication. On one occasion, being drunk, he had lost a parcel of some value, and in his sober moments could give no account of it. Next time he was intoxicated, he recollected that he had left the parcel at a certain house, and there being no address on it, it had remained there safely, and was got on his calling for it."[b] This man must have had two souls, one for his sober state, and one for him when drunk.

The paroxysms of intermitting insanity are sometimes followed by oblivion of their events in the lucid interval, and a fresh paroxysm brings them all to the memory. Here, of course, are a rational soul and a mad soul in the same tenement.

Shakspeare, aware of the frequency of the phenomenon in sleep-walkers, represents Lady Macbeth as walking in her sleep with her eyes open, though he makes the royal physician ignorantly infer that therefore she must be awake, and a gentlewoman of the court know better, —

[z] *Isis revelata*, vol. i. p. 320. sq.

[a] *Psychological Magazine*, vol. i. No. 1. p. 69.

[b] *A System of Phrenology*, ed. iii. p. 521.

"*Doctor.* You see her eyes are open.
Gentlewoman. Ay, but their sense is shut.

But a remarkable circumstance is that, though a particular sense appear torpid, it may be alive to *some* impressions. A sleep-waking female, mentioned by Lorry, could not be made to see or hear or be aware of the presence of any person but one, and him she evidently saw, and to him she used to address herself upon the subject of her dream. Dr. Pritchard gives an account of a boy who, in these paroxysms, became insensible to all external impressions, except that, when he happened to play on the flute, he sometimes perceived if other boys began to accompany him, and then evidently directed his attention to them.[c] The insensibility to external impressions in sleep-waking, as in common sleep, is not in the organs of sense or the tract of their nerves, but in the portion of the brain most immediately connected with them: and, if these portions are not torpid, and at the same time there is excitement either of a particular *kind*, as musical, for instance, or in connection with a particular individual, those impressions tell which are in relation with the excitement, while those which find all torpid with which they might be in relation are unnoticed. But, for this singular partial sensibility to take place, the portion of the brain in connection with the very extremities of the nerve of sense cannot be torpid: for, if it were, no excitement in relation to any object of that sense, no attention or direction of the thoughts, would avail. Such a portion is torpid sometimes. Negretti sat down to eat a bowl of salad: yet, though his thoughts must have been upon it and his attention directed to it, he ate first cabbage and then pudding, which his friends substituted for it in succession, without perceiving the difference. When he had asked for wine, he did not detect that they gave him water; when snuff, that he received coffee. On the other hand, if the portion of the brain in connection with a particular sense is not asleep, its objects may be perceived though presented unexpectedly. Signor Augustin heard slight sounds at a distance, and was set listening. I therefore cannot agree with Dr. Pritchard, who attempts to explain these differences entirely by generalising the remark made on Castelli's case by the reporters, and saying that, "when attention is by a voluntary act directed to the particular operation of

[c] *On Disorders of the Nervous System, &c.* p. 409.

sense, the perceptive faculty of the sleeper is perfect, even remarkably acute. But when his mind is distracted, his reverie presenting different objects, even loud sounds are imperceptible to him." If, on the other hand, a particular sense is not torpid, but the portion of the brain in immediate connection with its nerves sensible, impressions may not be perceived, on account of the excitement of the thoughts — of attention, in another direction; just as, when in study we become wrapt in thought, we cease to hear the chimes of a clock in our apartment: and, though a sensation take place, the mind may form a wrong judgment if imperfectly excited towards it; as when Negretti, if a blow was given him with a stick, or a muff was thrown at him, fancied in each instance it was a dog, — mistakes similar to those which we make, if addressed or touched when deep in thought. And, although a sense be nearly torpid, a powerful partial excitement and concentration of thought, such as happens in common dreaming when we successfully effect what we had attempted in vain when awake, may cause very slight impressions on that sense to be accurately perceived. Probably, not merely is the *intellect* partially much heightened, in some instances; but a *sense* rendered exquisite, so that a person may see with the eyes so much closed that others consider them shut, and perceive in what others call darkness. I shall mention a case of extraordinary sensibility to light at p. 653. *infrà.* The sensibility sometimes either quickly varies or becomes very peculiar in the paroxysm. For, while it was certain that my little patient in herdelirium saw perfectly all round her, I darted my finger rapidly towards her eyes, but the pupil did not lessen nor the lids wink. The same extraordinary phenomenon occurred in a case presently to be quoted from Dr. Abercrombie, and in another from an American journal. I made the experiment repeatedly on different days. Another singularity was that, though she evidently saw well around, she declared, on my holding up one finger, that there were two; on holding up two, she declared there were four; on holding up four, she said there was a large number. On presenting a watch to her, she could not tell the time, though she attempted carefully: she at length pronounced an hour, and persisted in it, but quite wrong. Once while looking at Baron Dupotet, she said he had a great many eyes, and then that his eyes turned right round in his head. In the delirium I always noticed one eye to be too near the nose. The

following case also exhibited either rapid changes or an extraordinary state of sensibility. Dr. Darwin relates the case of a young lady about seventeen years of age, who, every day for five or six weeks, had fits of violent convulsions, then retchings, next equally violent hiccups, then tetanus, and at last sleep-waking, becoming insensible, yet singing, quoting whole passages of poetry, and holding conversations with imaginary persons, and coming to herself with great surprise and fear, but with no recollection of what had happened. At length she could walk about the room in the fit without running against the furniture, and evidently had some external sense: for she took a cup of tea and expressed a fear that there was poison in it; and seemed to smell at a tuberose, and deliberated about breaking the stem, because it would make her sister so charmingly angry; once heard a bell, was less melancholy when the shutters were open, and impatient if a hand was held over her eyes or her hands were held down, saying, "She could not tell what to do, as she could neither see nor move."

I conceive that those portions of the brain that are connected with the nerves of the respective organs of sense may all be completely torpid; or only some of them; or not completely torpid; or some in one degree of torpidity and others in another; and that they may appear torpid when they are not, or more torpid than they are, from the attention being dull or directed to another quarter: that one or more may become exquisitely sensible, while the others are in various degrees of torpidity, and may fluctuate rapidly between sensibility and insensibility or be peculiarly deranged: that the partial intelligence of the brain may be of various degrees, and have various directions, and may act powerfully with very little external sense: and that great variations in every point may take place in the fits of the same individual, and even in the same fit. If to these considerations we add the force of habit, we shall explain all that is usually observed in sleep-waking. Negretti laid the table, waited, and put the things away, by habit; and, in places to which he had been accustomed, showed no confusion, but went through his business cleverly; whereas, in a place of which he had no distinct knowledge, he felt with his hands all around, and showed much inaccuracy. He struck himself against a wall severely, and against a door which they had intentionally shut. Galen says that he himself walked about in his sleep a whole night, till he awoke by striking against a stone that hap-

pened to be in his way. Habit will also be far more successful in the partial excitement of sleep-waking. The man who often went in his sleep to draw wine in the cellar had no difficulty, but if he accidentally awoke he had to grope his way back. He knew the way well, but when awake had the emotion of fear to check him; and, in addition to this, probably had not the intensity of partial excitement which prevailed in his sleep, so that his habit was less effective.

But, though partial torpidity and partial excitement, of various degrees and in various points of the brain, and excitement in relation to various individual external objects, and some derangement of the natural sensibility, may explain all the cases which I have described, some persons explain many of the phenomena by the operation of a new sense diffused throughout the surface, but most intense at the epigastrium and fingers, and adduce extraordinary cases in proof of their belief.

" There are, therefore, somnambulists who see," says Gall, after relating the cases quoted in p. 630. sq., "and the opinion of certain visionaries, who think that the perception of external objects takes place in somnambulists only by the internal senses, is refuted.

" Experience proves that somnambulists who have their eyes shut hit themselves when obstacles unknown to them are placed in their way, that they fall into holes, &c. When, with their eyes shut, they find themselves in a place familiar to them, they find their way, like blind people, by the aid of local memory.

" Just as the eye and ear may be awake in dreaming, so may other external senses. We perceive exhalations that surround us; we recognise a bitter or sweet taste of the saliva after a bad digestion; we feel heat, cold, &c. Some persons think that somnambulism is a completely extraordinary state, because somnambulists execute, during their sleep, things which they could not accomplish awake: they clamber on trees, roofs, &c.

" All astonishment ceases as soon as we reflect upon the circumstances in which we do the boldest things, and upon others in which we cannot. Any one in a balcony, furnished with a balustrade, could look down from a very high tower, and without resting against this balustrade. We walk without tottering upon a plank placed upon the *parquet*. To what will not boys accustom themselves in their rash sports? What do not moun-

taineers in the pursuit of the chamois, rope-dancers, tumblers, &c. perform? But take the balustrade from the balcony: let us but discover an abyss to the right and left of the plank, and we are lost. Why? Is it because we are not in a condition to walk upon the plank? No. It is because fear destroys our confidence in our powers.

"Now let us judge of the somnambulist. He sees distinctly what he is about to do, but the organs which would warn him of the danger are asleep: he is therefore without fear, and executes whatever his bodily powers allow him successfully to attempt. But wake him: instantly he will perceive his danger, and give way.

"All this is sufficient to establish that the nature of dreams and of somnambulism furnishes fresh proofs of the plurality of the organs."

Let us, however, now inquire what phenomena of a marvellous kind have been recorded.

We have the authority of an archbishop of Bordeaux for the case of a young ecclesiastic who in his sleep would rise, go to his room, take pen, ink, and paper, and compose good sermons. When he had finished a page, he would read it aloud, and correct it. Once he had written *ce divin enfant;* in reading over the passage he substituted *adorable* for *divin:* but, observing that *ce* could not stand before *adorable*, he added *t*. *The archbishop held a piece of pasteboard under his chin to prevent him from seeing the paper on which he was writing; but he wrote on, not at all incommoded.* The paper on which he was writing was then removed, and another piece substituted; but he instantly perceived the change. He wrote pieces of music in this state, with his eyes closed. The words were under the music: and once were too large, and not placed exactly under the corresponding notes. He soon perceived the error, blotted out the part, and wrote it over again with great exactness.

A sleep-waking boy at Vevey, thirteen years and a half old, was declared, by a committee of the Philosophical Society of Lausanne,—Dr. Levade, and Messrs. Regnier and Van Berchem, not only to discover things well by his touch, and to write, and detect and correct any error he might have made, but to write, with the same distinctness as before, what his master dictated, though a *piece of paper was put before his eyes.* I relate no other

wonders of him, because I lay no stress upon the circumstance of sleep-wakers sometimes apparently seeing in the dark or with their eyes shut, though it is unquestionable and occurred even in some of the cases which I have already detailed, since the sight may become so acute that darkness is light to them, and since the smallest aperture of the eyelids may be sufficient to see through, and access may not be totally impossible to the eyes, though they appear closed or are even bandaged. A case is related, by Professor Feder, of a Gottingen student, who, in his sleep, with his *eyes shut*, would select music, place it on his harpsichord, and play it expressively; write letters; tell that it snowed, and that a man was at the window of the opposite house, &c. A ropemaker at Breslau, would be seized with sleep in the midst of his occupation, and, when his surface, ears, and nose were perfectly insensible, and his *eyes firmly closed*, continue his business just if he had been awake, pursue his journey without missing the road, and, finding some timber in a narrow lane, pass over it as well as if awake, and once on horseback, in passing the river Ilme on his way to Weimar, let his horse drink, and drew up his legs to prevent them from getting wet; yet "he could not see when his eyes were forced open."[d] Dr. Schultz of Hamburgh speaks of a girl of thirteen, who, in her paroxysms, recognised all colours, and the number and stripes of painted cards, not only with her eyes closed, but *bandaged*.

In America, Dr. Belden, in 1834[e], very minutely detailed an extraordinary case, in which the sleepwaker, a girl of sixteen, did, in her paroxysms, every thing with the greatest accuracy that she was accustomed to do when awake, threaded needles, read, wrote, and corrected any omissions, although in darkness and with her eyes closed and most carefully bandaged. Sometimes she evidently saw and was directed by her eyes; for, when once the stair-door, which was usually left open, was fastened by the blade of a knife placed over the latch, she rushed from her room impatiently, and, extending her hand before reaching the door, seized the knife and threw it indignantly on the floor, exclaiming, "Why do you wish to fasten me in? Her eyes were sometimes wide open, and the

[d] These cases are quoted in *Isis revelata* from the *French Encyclopædia*, vol. xxxviii.; *Encyclopædia Britannica*, SLEEPWALKER; *Psychological Magazine; Acta Vratislav.* class iv. art. 7.

[e] *Journal of the Medical Sciences*, No. 28.

pupil dilated and apparently insensible. Generally they were closed, and that they then were extremely sensible would appear, because she almost invariably supposed it was day, and when advised to retire usually replied, "What, go to bed in the day-time?" Once, in the darkness of night, while preparing dinner, she observed a lamp alight and put it out, saying she did not know why people wished to keep a lamp burning in the daytime; and once, when the light of a lamp was reflected on the closed eyelid by a concave mirror, so diffused that the illuminated space could scarcely be distinguished, it caused a shock of such severity that she exclaimed, "Why do you wish to shoot me in the eyes." Some uneasiness was produced even when she was awake, although the experiment produced no pain in the eyes of the reporter. It is particularly worthy of notice, that once when she was writing out a song, with a black silk handkerchief stuffed with cotton bound over her eyes, and a person interposed a piece of brown paper between her eyes and the paper on which she was writing, she seemed disturbed and cried out, "Don't, don't." An apple being held before her, but higher than her eyes, which were well bandaged, she raised her head, as any one would if desirous of looking at something above him, and when asked its colour, answered correctly. She learnt backgammon in her sleep, and so well and quickly that she soon beat Dr. Butler, an experienced player: sometimes, like many somnambulists, she displayed an astonishing power of mimickry, though she never exhibited the smallest trace when awake. Her personality was double, for she recollected from paroxysm to paroxysm and forgot all in her waking state: playing backgammon, for instance, better in the second paroxysm in which she attempted it, and, when the paroxysm was over, declaring she never saw it played, and not knowing even how to set the men. The paroxysms were attended by pain, at an invariable spot in the left side of the head, often so excruciating, that she used to cry out, "It ought to be cut open, it ought to be cut open." As her sleep-waking became less perfect, her face less flushed, and her head less painful, she required more light: for once she declared, in her paroxysm, that she could not read with her eyes shut; and, when the doctor placed his fingers before her eyes, she could not read a word and said it was total darkness.

Lest, however, such cases as the four last should be doubted

in this country, let us remember that Dr. Abercrombie relates the history of a poor girl, who, when seven years of age, looked after cattle at a farmer's, and slept next a room often occupied by an itinerant fiddler of great skill and addicted to playing refined pieces at night; but his performance was taken notice of by her as only a disagreeable noise. She fell ill, and was removed to the house of a benevolent lady, whose servant she became. Some years after this change, she had fits of sleep-waking, in which, after being two hours in bed, she became restless and began to mutter; and, after uttering sounds precisely like the tuning of a violin, would make a prelude, and then dash off into elaborate pieces of music, most clearly and accurately, and with the most delicate modulations. She sometimes stopped, made the sound of retuning her instrument, and began exactly where she had left off. After a year or two she imitated an old piano also, which she was accustomed to hear in her present residence: and, in another year, began to talk, descanting fluently, most acutely, and wittily, and with astonishing mimickry and copious illustrations and imagery, on political, religious, and other subjects. For several years she was ignorant of all around her in the paroxysms; but, at about the age of sixteen, she began to observe those who were in her apartment, and could tell their number accurately, though the utmost *care was taken to have the room darkened;* and, when her eyelids were raised, and a candle was brought near the eye, the pupil seemed insensible to light. She soon became capable of answering questions, and of noticing remarks made in her presence, and in both respects showed astonishing acuteness. "Her observations, indeed," says Dr. Abercrombie, "were often of such a nature, and corresponded so exactly with characters and events, that by the country people she was believed to be endowed with supernatural power.

"During the whole period of this remarkable affection, which seems to have gone on for ten or eleven years, she was, when awake, a dull awkward girl, very slow in receiving instruction, though much care was bestowed upon her; and, in point of intellect, she was much inferior to the other servants of the family. In particular, she shewed no kind of turn for music."[f]

[f] *On the Intellectual Powers*, 4th edit. p. 294.

Howmuch duller so ever than the rest of the servants this poor girl was considered, it is evident that she had observed greatly and acquired a store of knowledge. She was probably very reserved and contemplative, and could learn in her own way only. The really cleverest children are often considered stupid; while the quick and prattling, who turn out but ordinary adults, are thought prodigies.

Now at last comes the special wonder: greater than that of the young priest or the Swiss boy. Dr. Petetin, perpetual President of the Medical Society of Lyons about fifty years ago [g], had a cataleptic patient who seemed perfectly insensible. While addressing her loudly with the view of rousing her, he accidentally moved his face from her head towards the epigastrium in finishing the sentence; when to his surprise she heard him distinctly. He made many trials, and found the same thing invariably take place: and then, making experiment after experiment, he discovered that she could taste, smell, and read, and read even through an opake body, by the epigastrium: and at last he found that speaking at one end of a conductor, the other end of which rested on the epigastrium, was quite sufficient to make her perceive. Van Helmont, a century and a half before, had declared that, after tasting some aconite, his head felt strange, and all his intellect seemed to have left his head and taken up its residence for two hours at his epigastrium. He was giddy for two hours, and then in his ordinary condition. [h] The simple explanation is, that Van Helmont was delirious through the narcotic; and at page 40. *suprà*, I mentioned that on one occasion of mental transport he actually saw his little soul in his stomach. Dr. Petetin tried other sleep-waking patients [i], and found the same phenomena; and in some that the ends of the fingers and toes had the same power as the epigastrium. Dr. Petetin secretly placed pieces of cake, tarts, &c. upon the epigastrium, and immediately the peculiar taste was perceived in the mouth: if they were wrapped in silk, there was no taste till they were uncovered. One patient distinguished a letter folded four times, and inclosed

[g] *Mémoire sur la Découverte des Phenomènes que présentent la Catalepsie et le Somnambulisme.* Par M. Petetin. 1787.

[h] *Demens idea,* § 11. sq.

[i] *Electricité Animale prouvée par la Découverte des Phenomènes Physiques et Moraux de la Catalepsie Hystérique, et de ses Variétés.* 1800.

in a semi-transparent box held by Dr. Petetin upon her stomach. Another patient, when a letter was placed upon her finger, said, "If I were not discreet, I could tell you the contents: but to prove that I have read it, there are just two lines and a half." She correctly enumerated the chief articles in the pockets of the company: and a Madame de St. Paul, if interrogated mentally only by means of a metallic chain, one end of which was placed on her epigastrium and the other on the interrogator's lips, or of a chain made by several persons, the first of whom placed his hand on her epigastrium and the last whispered in the hollow of his hand, heard perfectly, though insensible to the loudest voice if the chain were interrupted by a piece of sealing-wax.

These things seem calculated only to excite a smile; but, from that time to this, similar cases have been recorded in different countries. Baron de Strombeck published one, in which the phenomena were observed, noted down, and attested by three physicians as well as himself.[k]

Dr. Joseph Frank[l], in 1817, gave an account of a violent case of hysteria and catalepsy, in a married woman twenty-two years old, who, in her fits, was insensible to light, pricking, and the loudest sound, but heard the moment the doctor approximated his mouth to her epigastrium and spoke in a low tone, not audible to the bystanders. Still he spoke: and be it also known that the woman was so credulous as to have given herself up to certain empirics and old women; "so ardent in putting her trust in God that she prayed fervently day and night; and laboured under hysteria, which often gives a strong disposition to deceive and excite the interest and wonder of others. While comatose, she both tasted sugar and water applied to her epigastrium, though after the coma she could say only that something moist was there but could not tell what, and could hear nothing except the doctor's hand was on her stomach. When asked the name of a gentleman present, she was silent: but, as soon as Dr. Joseph Frank, whose hand was always on her stomach, took him by the hand, she

[k] *Histoire de la Guerison d'une jeune Personne par le Magnétisme Animal produit par la Natur elle même.* Par un Temoin oculaire.

[l] *Praxeos Medicæ Universæ Præcepta.* Leipsiæ, 1817. P. ii. vol. i. p. 495. sqq.

at once told his name; and, indeed, answered questions put to her by any person, and told all their names, provided they formed a chain by their hands among themselves and with Dr. Joseph Frank, and he had his hand on her stomach. The woman was always so obliging when the doctor had his hand on her stomach, that it must have been fortunate his name was Joseph. Dr. Bertrand gives several others, which had occurred up to the appearance of his work in 1826[m], and contends that the phenomena repeatedly appeared in the hysterical excitement of the Quakers, of the Cevennes, the Nuns of Loudun, and the Convulsionaires of St. Medard.

A case more recently occured in the Jervis Street Hospital, Dublin, and is recorded in a clinical lecture by Mr. Ellis.[n] A cataleptic female, Mrs. Finn, gave no signs of hearing an Æolian harp played close to her ears; and, after the fit, declared she had not heard it, nor recollected that cold water was dashed upon her, though it had made her scream violently. She had been spoken to on the epigastrium, palms, and soles, but it was not till long afterwards, in thinking on what had happened to her during the last two months, that she remembered having heard a voice one day on the pit of her stomach. "On the occurrence of the first cataleptic attack after this conversation, she was spoken to in the epigastrium as previously; and on the subsidence of the fit, she could report with accuracy every word addressed to her through this region. This experiment was often repeated, and always attended with similar results. She could hear the lowest whisper, or the ticking of a watch."

One occurred in a man in the Hospital della Vita at Bologna, in 1832[o], and it was probably the fame of this that caused the same city to be happy enough soon afterwards to produce another in a female who in her coma talked Latin, which she had never learnt, gave an accurate anatomical description in technical terms of the solar plexus, pancreas, heart, and first vertebra, detailed the pathological state of a lady whom she did not know, and the situation of places in Paris where she had never been; extracted roots of numbers, for instance of 4965,

[m] *Du Magnétisme Animal en France.* Par A. Bertrand. Paris, 1826.

[n] *Lancet*, May 2. 1835.

[o] *Bulletin des Sciences Médicales.* Bologna, 1832. or *Gazette Médicale.* Paris, Nov. 24. 1832.

though she had never learnt more than the first four rules of arithmetic, and unconsciously detailed various philosophical systems, and discussed others which were mentioned to her.[p]

Oh the waste of labour, time, and money spent in education, and books, and philosophical apparatus, when mesmerism is such a ready help! One hysterical young lady at Grenoble, whose case was read to the Philomathic Society of Paris, was able to get through a great deal of business, for in copying letters she read with her left elbow while she wrote with her right hand.[q]

I do not doubt the truth of the narration of all the cases of sleep-waking, excepting those in which there was extraordinary knowledge, patients saw through opaque bodies, or the epigastrium, fingers, and toes, were the seat of extraordinary perceptions: and these I shall defer considering till I speak of sleep-waking induced by art. The cases are too numerous, have occurred in too many places, at too many times, and under too many circumstances, are too naturally and respectably told, are all too similar and yet too diversified, and yet not marvellous enough, for a reasonable mind to doubt them. They are all evidently examples of partial torpidity and partial excitement, and some also of partial extraordinarily rapid change or peculiar derangement of various portions of the brain, and perhaps of some other parts of the nervous system. The phenomena ascend from the faintest common dreaming, or even from disturbed sleep, through plain sleep-walking, and somewhat singular performances, to the most astonishing. Every degree is morbid; and, to view the cases as any thing else than instances of bodily derangement, would be absurd. The attacks are sometimes periodical[r]; take place in bad health, and are worse in proportion as the health is worse; are frequently united with other diseases of the nervous system, — catalepsy, hysteria, epilepsy, delirium, &c., or are changes from these or change to these; occur, unless when chronic, most frequently when the

[p] See *Lancet*, Feb. 16. 1833.

[q] Bertrand, l. c. p. 458. sqq.

[r] Martinet mentions a watchmaker's apprentice who had an attack once a fortnight, and did his work well, astonished on awaking at the progress he had made. The fit began with heat at the epigastrium rising to the head and followed by confusion and complete insensibility, his eyes being fixed and staring. Negretti's attack was always in March. See *suprà*, p. 639.

sexual feelings and functions are establishing themselves and the former not yet gratified [s], and the whole young mind is undergoing the changes of the adult period; are often attended by pain in the head, and all the common symptoms of deranged distribution of blood and of morbid sensibility in that part; they have all the same exciting causes as other nervous diseases; the pre-disposition to them is sometimes hereditary [t]; and they require the treatment common to all other nervous diseases. To consider them as examples of the soul acting independently of the body in the disease, is discreditable to an author of the present day. Old authors regarded common dreams in this point of view; and I formerly quoted the remark,—that the soul must work very strangely, when so disencumbered of the activity of the brain, for us to dream "such perilous stuff as dreams are made of." (*Suprà*, p. 626.) The cases of double consciousness in those affected with the disease (*suprà*, p. 646.) ought to prove two souls to exist; and one of them to be able to get drunk alone in the case of the Irish porter, whose second consciousness showed itself only in his intoxication. Sleep-waking is neither more nor less than diseased sleep. The torpor far exceeds that of common sleep, and is a coma like that of apoplexy, hysteria, or epilepsy; though in the first of these the brain generally is prevented by pressure only from performing its functions. In epilepsy we have equal coma: in a moment the patient becomes insensible to mechanical violence, the loudest noise, and the strongest light: even when the disease is partial, as in two little boys whom I attended, in whose fits the eyelids only were convulsed and the head drawn back, the insensibility came in a minute, and as suddenly ceased, and was

[s] Of 50 cases which I have counted, 21 were apparently permanent, and 18 such occurred in males; 16 patients were females, and 13 of these from 13 to 25 years of age, and unmarried; of the 34 males, 16 were from 10 to perhaps a little above 20 years of age, and apparently all unmarried: 7 of the young patients were 16 years old. The chronic cases probably are more rare, but appear so large in proportion from attracting greater attention and therefore being oftener recorded.

[t] "Negretti's son was subject to it from boyhood." Dr. Willis knew a family in which the father and all the sons were sleep-wakers, and "the sons in their nightly discursions ran against and awakened each other." Dr. Pritchard, *Treatise on Insanity*, p. 459.

such that, during the minute of the fit, a pistol fired off in the ear of one was unnoticed. In common epilepsy and sometimes in hysteria we have coma, — perfect insensibility, and at the same time such high excitement of the parts of the nervous system which move the muscles that violent convulsions occur. In sleep-waking, it is an intellectual, and sometimes also moral, part of the nervous system that is excited in the midst of the torpidity, sometimes one part, sometimes another; and, in some instances, probably a heightened partial sensibility of parts concerned in external sensation. In neuralgia we have fits of violent excitement of nervous parts concerned in sense; in palsy of sensation, the reverse. In tonic and clonic spasms we have excitement of nervous parts concerned in motion; in palsy of motion, the reverse. We have these two portions sometimes in opposite conditions. The same holds good precisely of all parts of the brain: and these conditions, in all these cases, and in all other diseases of the nervous system, as fits of morbidly excessive sleep, may be purely functional, and occur in paroxysms: nay, most rapid changes of external sense may probably take place in the paroxysms, or even alterations different from changes of mere degree. Some may have ecstatic delirium, in which there is no loss of external sense, nor coma, but a sudden change in the internal feelings, so that the patient talks and acts like a fool, and in a moment the whole may cease and be forgotten, and the patient be as before: and this may be interchanged with fits of sleep-waking.

By certain processes, such as passing the points of the fingers at a short distance from a person in a direction from the face down the arms, trunks, and legs, with a degree of energy, the state of sleep, or sleep-waking, may actually, we are told, be induced. It is then termed *magnetic*, and the whole phenomena, *animal magnetism*. The patient becomes insensible to all around, but may have the inward senses augmented as in common ecstasis, — may sing well for the first time in his life, and talk so unguardedly as to disclose secrets. The external senses may become so impene-

trable, that a pistol fired in the ear is not heard, nor melted wax dropped on the body felt, nor ammonia applied to the mouth or nostrils perceived, although the gentlest word of the operator (*magnetiser*) is heard and answered, water similarly treated (*magnetised*) by him tasted and found ferruginous, and the gentlest touch of him recognised. A delightful feeling of ease and lightness is experienced, the body grows warmer, and perspires freely, though sometimes anxiety, palpitation, slight convulsions, and wandering pains take place. On the first attempt these occur generally without sleep-waking, and it is only after many trials (and sometimes they continue fruitless) that such a state is induced. On coming out of the sleep-waking, the person is unconscious of all that has occurred; but, when thrown into it again, recollects the whole and converses on it. The magnetiser can put an end to this state at pleasure: and, when he is a good magnetiser and the patient very susceptible, a single movement of the hand may instantly magnetise, and even knock down and kill; a look may magnetise: and we are told that all these effects may sometimes be produced at great distances by the mere volition of the magnetiser.

But this is not all. We are assured that matters often go much farther; that a person can often be so highly magnetised, not only as to taste magnetised water and recognise the magnetiser by hearing and touch, but even to perceive objects of sight, hearing, taste, and smell, by the epigastrium, fingers, and toes,—by the organ of touch, so as to read a letter by these parts [u], even though it be folded in several envelopes; nay more, to discover a person in the next room, though a wall intervene; to foretell events entirely relating to others, and describe things going on at incalculable distances, as well as learn the thoughts of persons present; to relate the most minute points regarding persons who touch them, though never seen before; to see the interior structure of his own body, and describe the seat and appearance of a diseased organ, predict the future events of a disease of either himself or others, and point out the remedy. However, I am not aware of any anatomical discoveries having ever been made, and

[u] This reminds one
"Of Rosicrusian virtuosis,
Who see with ears and hear with noses." *Hudibras.*

presume that blood would never have been seen flowing up the cava inferior and down the aorta unless Harvey had first taught the circulation; and I observe that the remedies always depend upon the country and the period, — that, in Paris, leeches to the anus and vulva, ptisans, baths of Barèges, and extract of nux vomica if the person has heard of Dr. Fouquier's treatment of paralysis, gummed water and gummed lemonade, diet drinks of borage, and M. Dupuytren's remedy of mercurialised milk procured by milking a goat previously rubbed with mercurial ointment, are ordered: and suppose that calomel, sulphate of magnesia, porter, and port wine would be called for in England; and that neither quinine for ague, nor iodine for bronchocele, were ever commanded before Pelletan and Dr. Coindet had made known their virtues.

This state is called *hellsehen*, *clairvoyance*, or *lucid vision;* and, if the lucidity extends to all objects of space and time, so that things long past relating to others, things passing at a great distance, and things to come, are revealed, it is *universal lucidity*, or *allgemeine klarheit.*

They affirm not only that water can be magnetised so as to taste chalybeate, but inanimate bodies made conductors no less than a chain of persons.

It was said to have been discovered by Dr. Mesmer, a very glutton in all that was marvellous, in the latter part of the last century, who, knowing that the magnet was much employed as a remedy, and hearing from Hell, a Jesuit, the professor of astronomy at Vienna, that he had cured himself by magnetic plates of a severe cardialgia, opened a house for curing every disease in this way, and began to imagine the existence of an universal magnetic power, distinct from that of the common magnet, depending upon a fluid pervading all living and inanimate matter, and the source of all in art and nature. To throw this fluid into persons, — to magnetise them, he manipulated as we have mentioned, and employed other processes which are now omitted. He travelled, performed many great cures, and often failed; was praised, and deservedly abused, for he adopted the course of all quacks, whether regular or irregular practitioners. He depreciated others, affected mystery, and extolled himself. He insisted that there was but *one health*, *one disease*, and *one remedy*, which

remedy, of course, *he* had discovered. He rubbed and pressed his patients, and touched them with an iron rod, made them sit silently in circles, in a room rather darkened and furnished with mirrors, music playing all the time. After him, a school was established at Lyons and Ostend by a Chevalier Barbarin, where no manipulations were used and all was accomplished by the energy of the operator's volition. Faith removed their mountains, and their motto was "Veuillez le bien — allez et guérissez." At a third school, that of the Marquis de Puysegur at Strasburg, very gentle manipulations were employed, and the operators made them frequently at some distance from the patient.

Such results appeared as caused a commission of inquiry to be ordered, in 1784, by the government of France. The whole was ascribed to imagination, imitation, and touching; the matter declined, and Mesmer retired to Switzerland. Still it was practised not only in the three first schools of Mesmer, Barbarin, and Puysegur, but assiduously cultivated in many parts of Germany, and lingered still among us, for a Miss Preston in Bloomsbury Square, who died lately, practised it during the best part of her life; and I recollect that, about twenty years ago, numbers went to a magnetiser at Kennington. I some years ago saw lectures upon it advertised in the prospectuses of the medical courses in German universities, — at Heidelberg for instance. Of late the subject has been revived among the physicians of Germany and France, and at Berlin a magnetic clinical ward has been opened; and a commission of the Royal Academy of Medicine sat in 1826, in Paris, to inquire into it anew.

J. B. Van Helmont, born at Brussels in 1577, certainly shows in his works that he was well acquainted with animal magnetism and practised it. His cures by its means, were, like most miracles, ascribed by the wicked to the assistance of the devil. His language is so distinct, that "we might almost conceive," says Mr. Colquhoun, "that we were reading the works of some disciple of Mesmer:" and indeed many Continental and English writers of the sixteenth and seventeenth centuries contended for an universal magnetic power, which produced the dependence and reciprocal action of bodies, and especially the phenomena of life; and allowed extraordinary effects to be produced in another living being, even at a great distance, by the will or imagination of

man. Cornelius Agrippa ab Nettesheym asserts that a man naturally, and without any miracle, unassisted by the Holy Spirit or any other, may convey his thoughts in the twinkling of an eye to another at any distance: "et ego id facere novi, et sæpius feci. Novit idem etiam fecitque quondam Abbas Trithenius." [x] A professor of philosophy at Padua, Petrus Pomponatius, born in 1462, had contended, before Van Helmont, for the power of the imagination or will of one person to send forth an influence upon another; and enumerated the conditions of the exercise of this power in nearly the terms of modern magnetisers. He too surpassed all, for he point blank declares that inanimate matter may obey this influence. "Cum hominis animæ voluntas et maxime imaginativa fuerint vehementes, venti et reliqua materialia sunt nata obedire eis." [y] Still Mesmer was the great restorer and modern establisher of magnetism in spite of great obstacles, so that the facts have been termed mesmerism; and, as the denomination animal magnetism is incorrect, and may lead to misconception, I shall in future adopt the word mesmerism. Even an arbitrary word in science is better than one devised from imperfect knowledge.

Those who ascribe all to imagination, consider the agitations and prophecies of the Delphian priestess of Apollo and the Sybils, and all ancient prophesies, the ecstacies of Dervishes and Santons, and of Shakers and Quakers, Irvingites, and of all ridiculous enthusiasts in what they strangely call religion, but which is all superstition and revolting irreverence to the infinite God of the universe, and the pretended miraculous cures of all ages, from the days of Serapis of Egypt to those of the blessed Paris of Paris [z], and of our own day, and of all countries, as only of a piece with mesmerism, showing how strongly fear or enthusiasm will work upon the brain and all the other organs. Others discover that magnetic influence has always been acknowledged, and even adduce a passage attributed to Solon, and preserved by Stobæus, to

[x] *De Occulta Philosophia,* l. iii.

[y] *De Incantationibus.* Basil, 1577. p. 237.

[z] Such ecstacies, &c. and miracles were worked at his tomb, that the government closed it, and forbad any more!

"De par le Roi, défense à Dieu
De faire miracle en ce lieu."

prove the antiquity of performing manipulations like those of magnetism to procure tranquillity :—

> "Τὸν δὲ κακαῖς νούσοισι κυκώμενον ἀργαλέαις τε
> Ἁψαμένος χειροῖν αἶψα τίθησ' ὑγιῆ."
>
> Sometimes the fury of the worst disease,
> The hand by gentle stroking will appease.

They adduce another from Plautus to show that manipulations were used in Rome to send persons to sleep. Mercury, proposing to knock a man down, says ironically in allusion to putting a child to sleep by gently rubbing it,—"Quid si ego illum *tractim* tangam ut dormiat." Sosia replies,—"Servaveris, nam continuas has tres noctes pervigilavi."[a] The Bible, of course, has not been left unquoted. When Naaman drove to Elisha's door in his chariot, and the prophet neither invited him in nor went out to him, but directed him to go and wash himself seven times in the Jordan, he was greatly disappointed at not being *touched* by the holy man. "But Naaman was wroth, and went away, and said, Behold, I thought, He will surely come out to me and stand and call on the name of the Lord his God, and strike his hand over the place, and recover the leper."[b] They believe there was mesmeric operation in these things: and consider them, and all the oracles, visions, prophecies, magic, and miracles of the pagan world, and those mesmerisers who are deists consider even the alleged supernatural things of the Jewish and Christian world, as not supernatural, but the result of this mighty power. Some are such enthusiasts, that they refer to mesmerism the instinctive application of our hand to a part in pain and rubbing it. The pressure and agreeable sensation go for nothing. The production of sleep by gentle friction is mesmeric. The mere circumstance of a gentle and continued impression has not the effect, because the sight of waving corn, the trickling of a brook, or the motion of rocking, does not produce sleep, nor can we rock or rub ourselves to sleep. The practice of the peasants in Bavaria, of rubbing their

[a] *Amphitryo*, act 1.

Consult *Lettres Physiologiques et Morales sur le Magnétisme Animal.* Par J. Amedée Dupeau. Paris, 1826.

[b] Kings, ii. 5. 11.

little ones from head to foot before putting them to bed, and the Oriental habit of uniting friction with the bath, is mesmeric. It is a great oversight in them not to adduce the habit of brute mothers to lick their little ones, as licking is friction with the tongue: but then to be sure brutes lick themselves also. It must however be an oversight not to adduce the habit of expecting our grooms to rub down our horses thoroughly night and morning. The verses of Martial referred to as implying mesmeric practice, are fully as applicable to grooms and horses: —

> "Percurrit agili corpus arte tractatrix
> Manumque doctam spergit omnibus membris." (iii. 82.)

Ignorant Mr. Mahomet and the rest of the shampooers! ignorant women who get your living as *rubbers* to the diseased! you imagine not that you are all *animal* magnetisers. The mesmeric process of rubbing horses, universal in civilized nations, would have been as good an example as that of a family in Dauphiné, "who have been in the habit of magnetising, from father to son, for centuries," and whose "treatment consists in conducting the *great toe* along the principal ramifications of the nerves;" or as that of the great toe of King Pyrrhus. It was irreverent to adduce a merely royal toe, when virtue is known to go out of the toes of his holiness the Pope, whose foot is therefore devoutly kissed by the faithful. The ancient medical employment of friction is mesmeric: and so must be all similar mechanical means; and among the rest the douche, which is liquid friction and percussion. I do not see why percussion, on the good effects of which treatises have been written, is not as mesmeric as friction. Mere touch does wonders, not by imagination, but mesmerically. A boy at Salamanca is mentioned who cured numberless persons merely by touching them with his hand. Many monks did the same. They forget to mention at the same time that an inanimate hand has great power in this way. It might be thought to have lost its mesmerism, but the mesmeric fluid is probably retained by the ligature around the neck, for the hand of a dead man just fresh from the gallows is to this day stroked over tumours to remove them. If any thing is mesmeric and not mechanical, this must be; as it is quite sufficient to draw the hand once across the swelling. Then again the efficacy of the *royal touch* has been known from the time of

Vespasian, who performed two miracles now ascertained to be mesmeric, to that of the Scandinavian princes, particularly St. Olaf in 1020, and even down to our modern kings, for whose mesmeric virtues the royal surgeon Wiseman, not through the mean craftiness of a courtier, but through philosophical conviction, stoutly vouches.[c] It is very remarkable that it was not simply hereditary and constitutional, but depended upon the individual being actually in office as king, and it is a loss, if not disloyal and radical, to consider our kings as no longer endowed with this virtue. George the Third gave up the pretension; but a king would still have thousands of patients if he would but practise: — a strong argument in favour of mesmeric influence. The practice of the imposition of hands and the manner of benediction are unquestionably mesmeric. The Chaldean priests are said to have practised this mode of treatment; as also the Indian Brahmins, and the Parsi; and the Jesuit missionaries inform us that the practice of curing diseases by the imposition of hands has prevailed in China for many years. The *imposition of hands* in blessing, and in the episcopal form of confirmation dates from the remotest antiquity, and originated in the view of imparting some holy effluence, just as I presume the imposition of the hands in correcting naughty boys and thrashing a man must have originated in the view of imparting something disagreeable. Among the eastern nations curative virtue was found to proceed from good men, if but even the *hem of their garment could be touched.* On the other hand, pernicious influence has always been acknowledged to proceed

[c] "I myself have been a frequent eye-witness of many hundreds of cures performed by his Majesty's touch alone, without any assistance of chirurgery; and those, many of them, such as had tired out the endeavours of able surgeons before they came thither." "This our chronicles have long testified, and the personal experience of many thousands can testify for his Majesty that now reigneth, and his uncle, father, and grandfather. His Majesty that now is having exercised this faculty with wonderful success not only here, *but beyond the seas*, in Flanders, Holland, and France itself." (p. 243.) The king always expressed his belief that the cure was effected by the grace of God, saying, at the time of the ceremony, "I touch, God heals;" and the pious and moral Charles II. touched 92,107 in twenty years, an average of twelve a day. *Chirurgical Treatises*, vol. i. p. 387. In 1684, Thomas Roswell was tried for high tresaon in having spoken contemptuously of the royal touch. — See *Wadd's Mems., Maxims, and Memoirs.*

from the eye. Every schoolboy remembers the passage in Virgil —

"Nescio quis teneros oculus mihi fascinat agnos." [d]

The word envy comes from invidio, and this from in and video. The Arabs dread the evil eye above all other mischiefs, and, if a stranger expresses admiration of any object belonging to them, they avert the calamity by passing over the object *a finger wetted with saliva.* Who is ignorant that the fierce look of man disarms the most ferocious brutes of their courage: that Pliny recommends breathing upon the forehead as a means of cure [e]; and that when a child complains the nurse often tells it she will blow away the pain. A dyspeptic friend of mine assured me that, on consulting a celebrated physician at an inland watering place, the doctor put his finger in mystic silence upon his forehead before feeling his pulse. Had it not been a little too late in the day, I have no doubt he would carry on such tricks like the notorious Dr. Streper, an Irish gentleman named Valentine Greatrakes, and a gardener named Leverett, who all, in the middle of the seventeenth century, cured thousands by stroking with the hand. Boyle and Cudworth both put themselves under the care of Greatrakes; and the Lord Bishop of Derry declared that he himself had seen "dimness cleared and deafness cured," pain "drawn out at some extreme part," "grievous sores of many months date, in a few days healed, obstructions and stoppages removed, and cancerous knots in the breast dissolved," by the Irishman. The gardener used to say that so much virtue went out of him, that he was more exhausted by touching thirty or forty people than by digging eight roods of ground. By means of the mesmeric fluid, some believers explain why a person cannot tickle himself; why, proverbially, when a friend is near, we think of him ("talk of the devil, &c."); and why, at the moment of death, distant friends have been said to see or hear the dying who happen to be thinking intensely of them so as mesmerically to influence them! [f]

[d] *Eclog.* 30. [e] *Hist. Nat.* xxviii. 6.

[f] A short and luminous account and defence of mesmerism will be found in Dr. Georget's *Physiologie du Système Nerveux,* t. i. from p. 268. to 301. 1821. Drs. Hufeland, Treviranus, Sprengel, Reil, Autenrieth, Kieser, Carus, &c. have believed in it.

For a good and entertaining history of the mesmeric phenomena as they ap-

Many of the phenomena of mesmerism are unquestionable, and no more than occur in health or disease. To yawn and fall asleep, have catchings of different parts, and various little sensations, is nothing wonderful. To become more or less insensible to all around, and more or less powerless in one or more or all external parts, and have one or more of the intellectual faculties or external senses highly exalted beyond their usual pitch in the individual, to have not only trains of thought and inclinations, but to speak and sing, walk, write, &c., in the midst of extreme insensibility, and afterwards to forget what has occurred, or even to remember it when the same state returns, and only then, is no more than what we occasionally observe in patients. But when we are requested to believe that persons perceive objects of sight through dead walls; perceive objects of hearing and sight, smell and taste, with their bellies and fingers or toes; know what is going on at a distance, what will happen in regard to persons and places with which they have no connection, know the history of persons whom they never heard of before, but who are put in relation (*en rapport*) with them by contact, speak languages they never learned, display scientific knowledge which they never acquired, and make anatomical and pathological observations in their own frames and those of others, the matter is too

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peared in a patient at the Hotel-Dieu in 1820, see *Expériences Publiques sur le Magnétisme Animal, faites à l'Hôtel-Dieu de Paris.* Par J. Dupotet, 3d edit. 1826. The woman had gastritis and aortic aneurysm, and is said to have described the inner surface of her stomach as raw with red pimples, and perceived a little pouch full of blood! The Baron is now publishing a work upon mesmerism in London.

For a complete history, see the *Diction. des Sc. Méd.* article *Magnétisme Animal.* The writer remarks that, in some Egyptian monuments, Anubis is represented near the patient as a mesmeriser, with one hand raised above the head, the other on the breast, while behind the patient another figure stands with the right hand elevated. See also the work of Deleuze, 2 vols.; the Marquis de Puisegur, 3 vols.; the Count de Puisegur, 4 vols.; Chardel, 1 vol.; Tardi de Montravet, 2 vols.; the *Bibliothéque du Magnétisme,* 4 vols.; *Archives du M.*, 4 vols.; *Annalen des M.*, 4 vols. Dr. Bertrand's excellent treatise *Du Magnétisme Animal, &c.*, 2 vols. Paris, 1826. He at first ascribed all to imagination; but was obliged at last to admit an unknown power. The reader of English only should consult *Isis revelata,* a work just published in two volumes, by Mr. Colquhoun of Edinburgh. It contains great information, and is highly amusing, not the less so perhaps for containing some nonsense.

wonderful for belief. I must be excused for not believing, till I have seen these things. Those who have read the history, and seen a little, of human nature, well know what deceptions have been practised upon the most wary; how long it has been impossible to detect the cheat; how bold and marvellous have been the impositions; and yet that at last the truth has come out, the impostor been covered with shame and the credulous believer with ridicule. Human testimony has been given to all kinds of absurdities and impossibilities in all ages, and may always be obtained from ignorance, superstition, enthusiasm, or interest, to any amount for any prodigy. It may be sometimes difficult to say what is contrary to the laws of nature and impossible; but the wonders of mesmerism are so astounding, and our experience of deception so abundant, that I find it more rational to suspend my belief than to admit them. Indeed, the most zealous mesmeriser must allow that deception on the part of the patient has frequently been detected; that women have appeared to be in so deep a mesmeric sopor that they have borne impressions of melted wax without the least agitation of countenance, and yet the whole has been proved an imposture: nay, that collusion between both parties has been discovered. We have seen that the same prodigies have been recounted as occurring in ordinary ecstacy and somnambulism as from mesmerism.

No one will allege that deception must have been impracticable, who knows the tricks performed by Asiatic and African jugglers[g]: and no one will allege that frequently no motive for deception was possible, who remembers that, besides interest, and even against interest and comfort, the desire to excite attention in ill conducted minds, and to excite attention or even simply to deceive in hysterical disease, is often intense; and no one will

[g] They will not only make a branch blossom before your eyes, but a seed spring up into a tree, and the tree bear fruit; throw one end of a long chain into the air, where it remains as if fixed, and send a dog up it, which disappears as soon as he has reached the other end: they will take the form of a cube, which then rises into the air, remains stationary over the heads of the spectators, and descends again; sit in the air four feet from the ground, one hand and arm being held up, the outer edge of the other resting on a crutch, while its fingers deliberately count beads; and will cause unblemished boys or women, or pregnant women, to see in ink the figure of any dead or absent individual that a third person may name. See Mr. Hunter, l. c. p. 284. sqq.; and Mr. Lane's recent work on Egypt.

urge the sense, attainments, and respectability of the believers, who has seen much of human nature, for he must know that the wisest have their weak points, and especially in regard to extraordinary things, which they often gloat upon like the most ignorant peasant, and that many who pass for highly informed men possess but partial information, and many who are distinguished for some one kind of discovery and pass for men of talent, possess but a moderate share of high and general intellectual power. The chief British advocate of all the miracles of mesmerism believes a thing to have been possible, which was an evident trick, and in which interest was the palpable and only motive. A Scotchman exhibited a boy lately in London, whom he pretended to be gifted with second sight. I went to the exhibition, and the boy told the colour and other qualities of things without seeing them, the names and ages of strangers in the room, &c. &c. But the father very fairly demanded that we should show him the objects, and tell him our names and ages, in short, make him acquainted with the facts, previously, in order that we might not say the boy was wrong when he was right. The boy, on being admitted into the room, without previous conversation with any person in it, invariably gave correct answers. A friend who accompanied me at once pointed out the trick. The father always addressed the boy before the little fellow uttered a word: and he began each successive sentence with a word, the first letter of which went to form the answer. For instance, if the object was of SILK, the father might begin — "*S*ee now you answer correctly; *I* know you will; *L*ook well before you speak; *K*now what you are about." Or each letter of a word of ten letters might be agreed upon, each being different, to signify a particular number. Thus if the letters of the word Cumberland were settled to signify 1, 2, 3, &c. in the order in which they stood, the father would begin, after a numerical question, with a sentence, the first letter of the first word of which signified the first number; then next with a sentence beginning with the letter signifying the second number. This was the principle, and of course there might be many variations of its application.[h] Mr. Colquhoun records, that "the father

[h] My friend's explanation will be given in a new edition of Dr. Brewster's *Letters on Natural Magic*, in which numerous deceptions are explained. A more copious work is by Eusèbe Salvert. *Sur la Magie*.

stated he had five children, all gifted in the same extraordinary way:" and, though Mr. C. acknowledges there is much room for deception, "*would strongly recommend*" (in italics) the investigation of the facts to professional men, because he has "sufficiently proved that the phenomena exhibited are of possible occurrence."[i] He would have us believe the case of Miss Macaray, of Liverpool, a Roman Catholic young lady, who became blind in June, 1816, when fifteen years of age, and accidentally discovered in the following October that she could read with her fingers the "Lives of the Saints," — the "Life of Thomas à Becket," and the Bible; having previously, after having become totally blind, presented a stole made by herself to her confessor. Whether the priest, for the glory of God and the church, suggested subsequent miracles of sight to her, or she imposed upon his Roman Catholic credulity, is a matter of speculation. She told an object placed under two plates of glass, by touching the upper plate of glass with her fingers; and could read with her fingers nine inches from the book, *by a convex lens which she touched!* Now this single circumstance proved the whole to be an impudent imposture. If the lens could have assisted her fingers to see, it must have been when they were placed at that particular distance from it at which the rays formed an image of the object; not when they were in contact with it. At its surface, a lens affords no image of an object: yet to her fingers, touching the surface of the lens, objects appeared magnified if the glass was convex, small if it was concave! This statement was a most unlucky mistake; she should have pretended to see with her fingers at the proper focal distance.[k]

Voltaire advises the Devil never to address himself to the faculty of physic, but to that of theology, when he wishes to impose upon mankind. However, in 1726, a poor woman at Godalming in Surrey, named Mary Tofts, pretended that, after a violent longing for rabbits, when pregnant, she brought forth these animals; and persuaded her apothecary, "Mr. Howard, a

[i] l. c. vol. ii. p. 339. sq.

[k] See *Annals of Med. and Surgery;* London, 1818, vol. ii. p. 385.; where it is remarked as singular that no person thought of ascertaining whether the point which she touched upon the glass was in a line between the object and her eyes; and whether an intervening opake substance, placed in this line, prevented her power of discriminating objects.

man of probity who had practised for thirty years," or, in common language, a highly respectable practitioner of great experience, that, in the course of about a month, he had delivered her of nearly twenty rabbits. George the First, not thinking it impossible, sent his house surgeon, Mr. Ahlers, to inquire into the fact; and the royal house surgeon returned to London, "convinced that he had obtained *ocular* and *tangible* proof of the truth," and promised to procure the woman a pension. The wise king then sent his sergeant-surgeon, Mr. St. André: and the sergeant-surgeon returned to town also a firm believer. They both returned with rabbits as *proofs!* and the rabbits had the high honour of being dissected before the king. An elaborate *Report* of their production and dissection was published by the sergeant-surgeon; and Whiston (of the faculty of theology indeed) showed, in a pamphlet (for a furious controversy arose between the believers and the unbelievers), that the miracle was the exact fulfilment of a prophecy in Esdras. An eminent physician, Sir Richard Manningham, backed by Caroline, then Princess of Wales, detected the cheat, and, on a threat of a dangerous operation and imprisonment, Mary Tofts confessed the whole. — Ann Moore of Tutbury, of extreme piety, and with a Bible always on her bed before her, pretended in 1808, sqq. to have taken nothing into her mouth for six years but the inside of some black currants once; and for the last four years and a half, nothing. There was no peculiar state of the nervous system to account for the circumstance. She was watched for sixteen days and nights in September, 1808: and members of the faculty of theology and medical practitioners testified to the truth of her statement: though Dr. Henderson showed, from many circumstances, to all rational people, that it was an absurd imposture. The Rev. Legh Richmond, in 1813, earnestly solicited her to undergo another watching. She consented; and, having caught a bad cold and thinking herself dying, she with great solemnity said, "In the face of Almighty God, and on my dying bed, I declare that I have used no deception," &c. Yet evidence of guilt and falsehood was at last obtained, attempts at concealment were useless, and she publicly expressed her contrition for her long continued imposture.[1]

[1] See an interesting work by my friend Mr. Hunter; *Sketches of Imposture, Deception, and Credulity,* — *Family Library.* London, 1737.

Gall was at considerable pains to examine into the facts of mesmerism. It was then in high favour with many, and adopted by many physiologists in their writings, so that he felt "the subject as delicate as it formerly was to proceed against sorcerers." [m] To avoid the charge of misrepresentation, he quotes the words of Kessler, who maintains that the epigastrium of the magnetised can perform the functions of all the five senses, and more acutely too than the special organs under ordinary circumstances; the fingers read the smallest print; the contact of the magnetiser's thumb render the ears unnecessary for hearing,— "the most common fact in the world, and the simplest experiment;" and complete vision take place with the eyes shut, so that all obstacles are avoided as dexterously in strange as in familiar places. "I will not bring a multitude of proofs, and the authentic testimony of many credible persons,' says Kessler, "but will mention only what I have seen again and again, and of the truth of which any one may satisfy himself favourably by his own experience." [n] Gall then, at great length, quotes Walther, the professor at Landshut, for a description of the stages of mesmerism, in the highest of which (*clairvoyance*) "time and space no longer present obstacles to the penetration of the magnetised," "who sees as distinctly into the interior of the magnetiser's body as into his own," the reason of which is, that "all the nervous system is an identity and a totality — a pure transparence without cloud, an infinite expansion without bounds or obstacles, — such is universal sense;" and, as "in the waking state the soul is more closely and intimately united with the body," and "natural sleep is a more intimate communication of our soul with the universal soul of the world; so in magnetic sleep our soul is united in the most intimate manner with the soul of the world and with the body, and with the latter not by means of the nervous system only, but immediately in all its parts and members, so that life is no longer a particularity, but original life." [o] "If any one," says Gall, "is convinced of all these marvellous fancies, and especially if he comprehends them, he is justified in asserting that such a doctrine exercises the most important influence upon the whole science of nature." Reil, so strangely brought forward as the rival of Gall,

[m] l. c. 4to. vol. i. p. 135. sqq.

[n] *Prüfung des Gallschen Systems.* Jena, 1805.

[o] *Phys.* t. ii. p. 244.

is the third whom he quotes: — "The estimable Reil," thus Gall generously terms him, "after having spoken of the abdominal ganglia as capable of becoming the conductors of sensation, says, 'the transition to the state of a conductor is so much more easy in living than in inanimate nature, that a communication may be established between the magnetiser and the magnetised, so that if the former chew pepper, the latter tastes it;'" "the magnetised are enabled to know by this evidence the configuration of their interior just as well as if they saw it with their external senses;" "a patient described the thoracic and abdominal viscera, the spinal marrow, the sympathetic nerve, and the solar plexus, as white threads and clear spots; some have heard sounds too low to be heard by others; some, with their eyes shut, have perceived objects, and especially men, in another apartment, and foretold, without ever making a mistake, what persons would come to the house: the magnetiser scratches himself, the magnetised itches at the same part; the former coughs, pricks himself, the latter also coughs and feels the prick[p]: the magnetiser takes wine and pepper into his mouth,

[p] This equals Sir Kenelme Digby, who solemnly assures us that a gentleman, having had his hand wounded in a duel and suffering great pain, found the pain suddenly cease when Sir Kenelme dissolved some powder of vitriol in water, and put into the solution the *bloody* garter with which the wound had been bound up. A few hours afterwards, however, he took the garter out of the solution and dried it before a large fire; but "it was scarce dry before the wounded gentleman's servant came roaring that his master felt as much burning as ever he had done, if not more, for the heat was such as if his hand were twixt coales of fire." He desired the man to return home, saying, "his master should be free from that inflammation, it may be, before he could possibly return unto him."—"Thereupon he went, and at the instant Sir Kenelme did put again the garter into the water: thereupon he found his master without any pain at all. To be brief, there was no sense of pain afterwards, but within five or six dayes the wounds were cicatrised and entirely healed." (*A Late Discourse made in a Solemne Assembly of Nobles and Learned Men at Montpellier in France*, by Sir Kenelme Digby, Knight, &c.; rendered faithfully out of French into English, by M. White, Gent., ed. 2. London, 1658. p. 6. sqq.) I may mention that the knight anticipated another folly and imposition, just as it may be with different practitioners, — Hahnemannism, or homœopathy, by pointing out an undoubted remedy on the principle of *similia similibus*. "Tis an ordinary remedy, though a nasty one, that they who have ill breaths, hold their mouths open at the mouth of a privy, as long as they can, and by the reiteration of this remedy they find themselves cured at last." p. 76.

and both taste them: the magnetised distinguishes magnetised from common water, foretells the commencement and duration of the paroxysm of his diseases, and points out the remedies." [q]

Gall, with that beautiful and playful irony which so characterised him, and with which he delighted to annihilate his adversaries' absurdities, after remarking that the human mind always turns in the same circle, — that Plato and Socrates had taught that our souls knew every thing originally, were in intimate communication with the universal soul of the world, and that their connection with the body did but impede the free use of their knowledge, avows that, if, in mesmeric sleep, our soul becomes intimately united with the soul of the world, none of the incredible tales of mesmerism can be doubted. "It is a trifle to hear a poor peasant, born far from Upper Saxony, speak the dialect of that country in its purity and with all its inflexions, and possess the gift of *unknown* tongues: to see another stupid peasant, ignorant of French, read correctly and understand a French book applied to her stomach. To read with the fingers, to know the hour by the watch in my pocket, to see through walls and houses, and perceive at a distance a person who will come to the house, are all wonders explicable by the intimate connection with the universal soul of the world. We thus see that if ever a great truth was promulgated, it is the doctrine of predestination and pre-established harmony. Magnetism proves, in the most peremptory manner, that every thing in the universe is not only concatenated, but completed. The dialect of Upper Saxony, the French language, my watch, the visit of the stranger, the letter of a lover which you fancy is so snugly concealed in your bosom, are concatenations of the world as necessary as the sun is to the universe. Say, now, what can be concealed from us either present or future?"—"We will not ask how the soul can be united intimately with the body and with the soul of this world at the same time; how it can be confined in its narrow prison and at the same moment detached from all its ties; how the soul of the magnetiser and the magnetised can be mingled, and afterwards separated again." "Unfortunately," he continues, "scientific discoveries still have to be made by the long and laborious method of experience, notwithstanding the magnetised

[q] *Archiv. für Physiol.* b. vii. st. 2. s. 232.

see all their internal structure in the clearest manner, and magnetism has been practised so long."

The result of Gall's investigation was this:—"Neither we, nor any other dispassionate observers, who have been present at the famous experiments of which such wonderful accounts have been given, have witnessed any thing supernatural or contrary to nature: we ought therefore to abandon the belief of the metamorphosis of nerves (the performance of the function of one nerve by another) to those who are better organised for the marvellous than ourselves."

It being, however, impossible to deny such facts of mesmerism as occur in some nervous diseases, are they to be ascribed to mere imagination — an excitement of the feelings by the gesticulations and proximity of the manipulator [r], or to the operation of an unknown power? Gall admits this power, and even does not reject the hypothesis of its connection with a fluid. "How often in intoxication, hysterical and hypochondriacal attacks, convulsions, fever, insanity, under violent emotions, after long fasting, through the effect of such poisons as opium, hemlock, belladonna, are we not in some measure transformed into perfectly different beings, for instance, into poets, actors, &c.?"—"Just as in dreaming, the thoughts frequently have more delicacy, and the sensations are more acute, and we can hear and

[r] "Among all the phenomena, however," says Professor Dugald Stewart, "to which the subject of imitation has led our attention, none are, perhaps, so wonderful as those which have been recently brought to light, in consequence of the philosophical inquiries occasioned by the medical pretensions of Mesmer and his associates. That these pretensions involved much of ignorance, or of imposture, or both, in their author, has, I think, been fully demonstrated in the very able report of the French academicians; but does it follow from this that the *facts* witnessed and authenticated by those academicians should share in the disgrace incurred by the empirics who disguised or misrepresented them? For my own part, it appears to me, that the general conclusions established by Mesmer's practice, with respect to the physical effects of the principle of imagination (more particularly in cases where they co-operated together) are incomparably more curious than if he had actually demonstrated the existence of his boasted science: nor can I see any good reason why a physician, who admits the efficacy of the *moral* agents employed by Mesmer, should, in the exercise of his profession, scruple to copy whatever processes are necessary for subjecting them to his command, any more than that he should hesitate about employing a new physical agent, such as electricity or galvanism." *Elem. of the Phil. of the Human Mind*, vol. iii. p. 221.

answer: just as in ordinary somnambulism we can rise, walk, see with our eyes open, touch with the hands, &c.; so we allow that similar phenomena may take place in artificial somnambulism, and even in a higher degree."—"We acknowledge a fluid which has an especial affinity with the nervous system, which can emanate from an individual, pass into another, and accumulate, in virtue of particular affinities, more in certain parts than in others."—"We admit the existence of a fluid, the subtraction of which lessens, and the accumulation augments, the power of the nerves; which places one part of the nervous system in repose, and heightens the activity of another; which, therefore, may produce an artificial somnambulism."[s]

A rigid mathematician, La Place, observes that, "of all the instruments which we can employ, in order to enable us to discover the imperceptible agents of nature, the nerves are the most sensible, especially when their sensibility is exalted by particular

[s] It may be interesting to mention an observation which Gall made upon himself by chance, and which, independently of the phenomena of mesmerism, confirmed him in this opinion. Having, while in contemplation, placed his hand upon his forehead, and walking backwards and forwards several times with his fingers over the hairy part of the front of his head, at about the distance of an inch, he remarked a gentle warmth, like a vapour, between his hand and the upper part of his cranium: he felt a heat ascend towards his shoulder and cheeks: heat in the head and chilliness in his loins. The same thing having recurred several times arrested his attention, and he repeated the experiment, and always with the same results. If he continued to move for some moments, with his hand suspended, the same phenomena increased. "The eyes become painful, and tears run down; the tongue can no longer articulate, twitchings of the face occur, respiration grows laborious, and sighing and oppression follow; the knees tremble, and totter: and some hours of repose are required to restore him perfectly.

"He has often, by the continued movement of the hand, produced similar phenomena in persons not previously aware of them. He produced even deep and prolonged fainting: he has, in regard to this peculiarity, a particular affinity with persons of both sexes who have fine and rather curly hair. They only act upon him in this manner, and he is able to distinguish, by this singular impression, if it is an individual of this description or not, who, at a fixed distance, in a numerous company, moves his hand over the superior anterior part of his cranium. On the other hand, he can act upon persons of this constitution only. The rapidity with which he loses his senses, and especially the extremely disagreeable impression produced by an inexplicable depression, have prevented him from pushing the trial beyond this and obtaining farther results."

causes. It is by means of them that we have discovered the slight electricity which is developed by the contact of two heterogeneous metals. The singular phenomena which result from the extreme sensibility of the nerves in particular individuals have given birth to various opinions relative to the existence of a new agent, which has been denominated animal magnetism, to the action of the common magnetism, to the influence of the sun and moon in some nervous affections, and, lastly, to the impressions which may be experienced from the proximity of the metals, or of a running water. It is natural to suppose that the action of these causes is very feeble, and that it may be easily disturbed by accidental circumstances; but, because, in some cases, it has not been manifested at all, we are not to conclude it has no existence. We are so far from being acquainted with all the agents of nature, and their different modes of action, that it would be quite unphilosophical to deny the existence of the phenomena, merely because they are inexplicable in the present state of our knowledge." [t]

Cuvier fully admits mesmerism : — " We must confess that it is very difficult, in the experiments which have for their object the action which the nervous system of two different individuals can exercise one upon another, to distinguish the effect of the imagination of the individual, upon whom the experiment is tried, from the physical result produced by the person who acts for him. The effects, however, on persons ignorant of the agency, and upon individuals whom the operation itself has deprived of consciousness, and those which animals present, do not permit us to doubt that the proximity of two animated bodies in certain positions, combined with certain movements, have a real effect, independently of all participation of the fancy. It appears also clearly that these effects arise from some nervous communication which is established between their nervous systems." [u]

I have no hesitation in declaring my conviction that the facts of mesmerism which I admit, because they are not contrary to established morbid phenomena, result from a specific power. Even they are sometimes unreal and feigned, and, when real, are sometimes the result of emotion, — of imagination, to

[t] *Théorie Analytique du Calcul des Probabilités.*

[u] *Anatomie Comparée*, t. ii.

use common language; but, that they may be real and independent of all imagination, I have seen quite sufficient to convince me.

In May, 1829, I was introduced to Mr. Chenevix by Dr. Hodgkin, and, as that gentleman had persuaded himself, theoretically and practically, at Paris, of the truth of mesmerism, I seized this opportunity of commencing an experimental examination, by availing myself of his offer to mesmerise any person I might present to him. I saw him mesmerise two girls at his own lodgings in Old Burlington Street, and took him several times to St. Thomas's Hospital. The two girls appeared to fall fast asleep by the process: but, though I watched them very carefully, I might be deceived, and, as they were well known to Mr. Chenevix, and had been mesmerised before, I drew no inference. At St. Thomas's Hospital, I selected female patients at random from my list of their names, and neither he had seen them nor they heard of him or mesmerism. Each was manipulated alone in a private room. On manipulating a patient of a colleague, who selected her himself, she had an hysterical fit, at which I was not surprised, as hysteria was her complaint and the least emotion at any time excited a paroxysm. He endeavoured to put an end to it in vain. On a second occasion, a violent fit recurred and his attempts to calm it were fruitless. He manipulated six other young females, with no effect, except that one, labouring under chorea, said her head was light and heavy alternately, and menstruated two days afterwards for the first time during three months. An epileptic woman fell asleep, apparently, on the two occasions she was mesmerised: yet we found that she was not asleep the second time, and she declared she had not been asleep the first time, though on both occasions she felt drowsy. I did not venture to conclude she was asleep, but the redness of her eyes and cheeks, the heaviness of her look, and every circumstance make me now believe she was asleep the first time, for I have seen many mesmerised persons fast asleep, who afterwards denied it. Pain was produced in her arm, and afterwards in her head, and presently recurred by manipulating in another direction; from this I inferred nothing then, but I have since then witnessed such phenomena so frequently, that I do not doubt their reality and their production by the manipulator. I remained unconvinced

till another female was mesmerised. She was an ignorant Irish girl, and unprepared to expect any thing. In a minute she plaintively entreated Mr. Chenevix not to proceed. The manipulations "drew weakness into her, and made her feel faint." She next complained of pain in the abdomen; on a few transverse movements she said the pain was gone: the same thing occurred several times, and once pain was complained of in the chest, but ceased perfectly after a few transverse movements. He darted an open hand towards one of her arms, and told her to raise it; she could scarcely move it: after a few transverse movements, she declared the stiffness and uneasiness were gone, and she moved it as well as the other. He produced all the same effects on the other arm, and then upon one leg. Her eyes were closed as perfectly as could be, and, a piece of paper weighing, perhaps, a grain, being placed upon one foot, she instantly was unable to raise it; the paper was removed, and she raised it directly. All these things were repeated again and again, I telling Mr. Chenevix, in French, which part I wished to be rendered powerless and which to be restored and she being prevented as much as possible from seeing. "Deception was impossible. Mr. C. looked round at me, and asked, in French, if I was satisfied. I really felt ashamed to say no; and yet I could scarcely credit my senses enough to say yes. I remained silent. He then asked me, still in a language unintelligible to the patient, 'shall I bring back a pain, or disable a limb for you once more.' I of course requested that he would do so. He complied instantly, giving her a pain in the chest once, and disabling her several times from moving her limbs, and removing those effects at pleasure, according to the intentions he avowed to me; the whole taking place exactly as it had done in my former trial with this woman."[x]

From this time I was satisfied that such a power as mesmerism exists, and hoped some day to inquire into it. I had no opportunity, however, before the arrival of Baron Dupotet in this

[x] I allowed Mr. Chenevix to publish my memoranda of what I saw. They will be found in the *London Medical and Physiol. Journ.* for Oct. 1829, which contains the last of a series of papers by him on mesmerism. He did not print them with perfect fairness, but omitted two or three comments, and I think facts, unfavourable to mesmerism, in regard to those cases in which the effects were none or doubtful.

country a few months back. As mesmerism is extolled in nervous diseases, I selected three epileptic patients, a male and two females, at University College Hospital, in whose disease I despaired of doing any good: and one hysterical female, who was said to have fits at such very distant intervals that I really could not tell whether she had any thing the matter with her, and who would not have been allowed to remain in the Institution. Several students and other gentlemen and myself submitted to the manipulations. On some gentlemen no effect was produced, but the process was not repeated above once or at all in them: of the greater number, some experienced a tingling or some strange sensation in the arms, legs, or face, frequently with little twitchings, an oppression and unusual heaving of the chest in respiration: and some always felt a heaviness or unusual sensation about the forehead, and even drowsiness, convincing them that they were under some strange influence, and on repetition experienced nothing more; I was mesmerised frequently, and always but once with the effect of tingling and twitchings only. Those who had never heard of tingling and twitching being the result, but conceived they were to be sent to sleep, experienced these effects abundantly; and many, who sat down laughing at the whole as nonsense, honestly confessed they were affected by some influence. Some of these had witnessed the soporific power of the process, and believed in mesmerism, like myself, and yet none could be sent to sleep. A visiter one day was put to sleep, but he never returned, and I did not see him. The four patients were sent fast asleep, the man always, and in from five to ten minutes; occasionally in longer time, occasionally in less. One of the epileptic females was manipulated very often before she slept, although she was delighted at the process and mortified whenever she was not subjected to it with the others. At length, however, she began to sleep under it; and once was sent to sleep in a few moments; but the process often failed with her. The other was for a great length of time sent to sleep invariably; but a curious circumstance at length occurred,—a few moments after she had lost herself in sleep she awoke, and it was impossible to give her longer sleep than for a few moments. This always happened repeatedly during the process, till Baron Dupotet was too tired to continue it: and it happened in every process for a long while.

At length, however, she was put to sleep again for the same time as before. The patients, when about to sleep, either showed a fixed stare, or they looked heavy and their eyelids gradually dropped or winked; their breathing became heavy; and sometimes they changed from waking to sleeping in an instant. When they were asleep, the head nodded or fell in one direction or another, the arms fell, they breathed loud or even snored. In some, twitchings of the fingers, feet, arms, legs, or face took place: in the hysterical girl the eyeballs rolled rapidly from side to side, or the lower lip was raised and depressed. These movements were the more striking that they alternated. On awaking, she never could open her eyes; but, on the Baron's making a few transverse passes above and below them, she opened them instantly. This invariably occurred: I and others every day made the same passes in vain. If we raised her eyelids, they instantly fell. We begged her to open them; but, till the fingers of him who had mesmerised her made transverse movements, they remained closed, however long we waited. In the rest, the sleep lasted a short time only: from a few minutes to a quarter of an hour: but in her it was very protracted; it was often so profound that she did not feel pricking nor pinching; and it seldom ceased till put an end to. This the Baron always did instantly at our desire, by transverse movements; when she got up, rubbing her eyes and looking drowsy for a minute, and then walked away as if nothing had occurred. The man often on awaking complained of a pain in some part or other, or some very strange sensation, which was immediately dissipated by transverse movements. At first he liked the process and prepared the chair with delight: but, after a time, he took a dislike to it, and at length requested not to be mesmerised, but to trust to medicines for his cure, and I of course did not oppose his wishes. Yet at both periods the effects were precisely the same upon him.

One of the students tried the process upon an epileptic girl, a patient of the gentleman with whom he lived at the distance of several miles from the College, and sent her presently off to sleep for several hours. He offered to bring her to the Hospital, as she was so susceptible of mesmeric influence; and she came three times a week. Her eyelids were always closed presently: and she never could open them till the Baron made transverse passes around them. I always attempted, but in

vain; and, if I opened them forcibly, they immediately shut again. After the Baron had done this, she always was sent asleep rapidly; and it was invariably remarked that at length she made one deep inspiration, and was then in a comatose sleep. This deep inspiration, the Baron informed me, is the uniform precursor of the coma. From this moment, we could do what we pleased without waking her, — halloo in her ears, dash her arms in any direction, pull her hair out, pinch her hand, put snuff up her nose: she was perfectly insensible, breathing placidly, and slept on in spite of any attempt to awake her, till the Baron made two or three transverse movements, when she instantly awoke. These phenomena were too striking and invariable for any rational person to disbelieve that some peculiar power had been in operation. Still, though awake, she generally could not open her eyes till transverse passes had been made around them. Her lower jaw was always firmly closed in her sleep, so that none of us could open it: but the Baron always caused it presently to open on moving his finger along it or holding his hand in contact with it: it was opened more slowly by manipulations made without touching her. On one occasion he held his finger near the meatus of the ear, and she presently heard, and from that time heard more or less and talked, especially if he operated again upon the ear; but after she was awakened she knew nothing that had passed in her sleep-waking. Still she was mesmerised many times before she answered questions: she heard a noise, and this roused her sufficiently to make her talk of what was present in her mind, but her words had no relation to the question. At length she began to speak to every question; and, on one occasion, on being teased again and again to give an answer when she repeatedly declared she could not, she fell into a violent rage, rose, seized the inquirer, shook and pushed him with both hands, and on being forced into a chair, after resting quiet a few minutes, she rose and made at the same person again very fiercely, and, sat down at last with difficulty, pale with rage, and her hands quite cold. Baron Dupotet thought it right to awaken her, and did so immediately, when she smiled with her natural good humour, and, on being addressed, proved herself to be in complete ignorance of all that had just passed.

The power of mesmerism was shown as strikingly though differently upon one of my two epileptic female patients. She ceased

to have epilepsy; but fell into fits of ecstacy, which I described at p. 629., perfectly insensible, though with her eyes open, chattering, mimicking, relating stories, &c. This state could be put an end to by mesmerising her. Generally she was restored in less than a quarter of an hour, even after this state had continued many hours, or even for a day or a week; once or twice it resisted long manipulations, but they continued, excepting once, till put an end to by the process, and that once, I understood, she fell back very soon into the state again. These attacks, I have already said, changed to ecstatic delirium; in the fits of which she was in possession of all her external senses, and these attacks were terminated by mesmerism, just like those of simple ecstacy or sleep-waking. They ended with momentary sleep. While sitting before the magnetiser, looking attentively at him, and saying all sorts of ridiculous and witty spiteful things, pale, with the countenance of a maniac, she suddenly seemed lost, her eyes rapidly closed for a moment, then opened, she looked astonished, and was in her perfect senses, smiling amiably, behaving in the most proper manner, in short, in full possession of her intellect and feelings. This phenomenon was, if possible, more striking than the sudden awaking of those who were in a state of coma. It occurred again and again and again for weeks, and the young gentleman under whose care the patient was in my absence from the hospital, succeeded like Baron Dupotet in bringing her to herself, and even two or three times when the latter had not been able through the state of exhaustion in which he was from having magnetised very often and long in the course of the day.

These are the phenomena which I have witnessed. To ascribe them to emotion and fancy, to suppose collusion and deception, would be absurd. They must be ascribed to a peculiar power; to a power acting, I have no doubt, constantly in all living things, vegetable and animal, but shown in a peculiar manner by the processes of mesmerism. I have witnessed its power at least three times a week for two months: and should despise myself if I hesitated to declare my decided conviction of the truth of mesmerism. I am willing to believe that a sleep-waker may prophesy morbid changes in himself with accuracy, as the boy mentioned by Gall predicted the termination of his fit if his friends would lead him into the garden, and the girl mentioned by Lord Monboddo predicted the cessation of her disease with

equal accuracy. I cannot forget that a minute portion of semen masculinum, probably far less than a drop, will transmit a father's structure, mental and bodily character, in the minutest points, even idiosyncracies of affection from various articles of food and medicine, and from morbid influences, so that the offspring may never take a particular contagious disease or not take it till a certain time of life, just like the father.

This declaration will excite a smile with almost every body; for, since the report of the French commissioners in 1784, it has been customary to ascribe all mesmeric phenomena to imagination or deception. But I set no more value upon reports of French commissioners than the reports are worth. I know their reports on Gall's labours (see *suprà*, p. 329. sq.), contradicted by themselves in their subsequent report on M. Fleuren's experiments; on Le Gallois' experiments, so well opposed by Dr. W. Phillip; their injustice to Dr. Tiedemann; and afterwards to Dr. Vimont. I have never yet declared an opinion upon a new truth that I have been obliged to retract. Phrenology has now advanced to its firm establishment; Human Glanders is universally admitted; Auscultation is invariably practised except by the wretchedly ignorant: Quinine, Prussic acid, Creosote, are now in daily use. I stood abundant ridicule for advocating these, and will now stand more ridicule with the same firmness and the same silent pity [y] or contempt which I have always felt for my opponents, till I see, as I shall, the truth of mesmerism also admitted and the world forget that it was ever doubted. Ignorance and party feeling are more unblushing when many are united officially, than when all is left to private and individual discussion. For expressing opinions favourable to mesmerism, two French academicians were expelled, and Mr. Chenevix I heard censured after his death as a fellow of the Royal Society by the President from the chair. The first French commissioners strangely referred all the effects which they witnessed to imagination, imitation, and touching. Now the influence of touching must have been different from that of imagination, as they employed two distinct words, and therefore all could not have been imagination even in their view. Franklin was so

[y] "Rideat me ista dicentem, qui non intelligit; et ego *doleam ridentem me;*" said St. Austin. *Isis revel.* vol. i. p. 81.

generally absent and paid so little attention that he ought not to have signed the report, and seems to have taken the absurdity of the thing for granted. The celebrated Jussieu refused to sign it, and made a special report of his own.[z] I have seen so much of what is wrong, in bodies and in individuals, that the opinions of the former and of the latter, whatever may be the rank, title, office, power, riches, or scientific character of the parties, never are regarded by me beyond their own simple worth.

But I have never witnessed more than what, it is certain, takes place in health and disease. I have seen persons sent to sleep, I have felt and heard others declare they had tingling, and heard some declare they had various other sensations and pains, I have seen twitchings, convulsions, and spastic contractions of muscles, loss of power of muscle, and the most profound coma; and I have seen these evidently and instantly removed by the process. I have seen one sense restored in the coma by the process, so that the person was insensible in taste, smell, sight, and yet heard and answered questions well. I have seen paroxysms of sleep-waking and ecstatic delirium, which had been originally induced by its disturbance of a system already epileptic, put an end to evidently, and in general quickly, by mesmerism. But I have not witnessed persons seeing through walls or pasteboard, nor tasting or smelling with the epigastrium or fingers; nor speaking or understanding languages they had never learnt; nor telling the circumstances past, present, and to come of persons they had never heard of before. Yet I have persevered with patience and docility. Often have I seen Baron Dupotet speak at the epigastrium and finger ends of the ecstatic and comatose patients: often heard him address them in a language with which they were unacquainted: often ask when they would have another fit; but nothing, which, till I witness such things, I must consider supernatural, has yet occurred. He has frequently said that these phenomena would soon occur, — that the patients would probably soon become *clairvoyans:* but no. No marvel has yet presented itself in my experience: nor has any good been yet effected in the diseases of my patients; but the perfect coma induced in some of

[z] *Rapport de l'un des Commissaires, A. L. Jussieu, chargés par le Roi de l'Examen du Magnétisme Animal.* Paris, 1784.

them would be an inestimable blessing in the case of a surgical operation, which I am positive might have been performed without the slightest sensation on some of the female patients, exactly as took place at the Hôtel-Dieu, where a cancerous breast was removed in mesmeric coma from a poor woman without her knowledge. I have no doubt that I shall in time see all the established phenomena of sleep-waking, — writing, reading, and doing endless things even better than in the waking state. But, before I see, I cannot believe more. I cannot believe that even those strange phenomena are produced by it which some declare to occur occasionally in plain sleep-waking, because I must see such sleep-waking before I believe it. Yet I will continue a little longer with docility to inquire and learn, for of Baron Dupotet's perfect good faith I entertain no doubt, however credulous he may be.

The observations of the late French commission agree with mine; but they go farther. Sometimes there was no effect; sometimes but slight effects; sometimes decided effects, as sleep, extreme insensibility, and muscular movements on the direction of the fingers of the mesmeriser, though sometimes none, and sometimes with scarcely uniformity enough for any one to assert that the movements resulted from it; sometimes insensibility of a particular sense dissipated, so that perfect coma was exchanged for sleep-waking, or the whole coma dissipated at the pleasure of the mesmeriser by transverse movements.

They saw a large variety of the more wonderful, but established phenomena of sleep-waking, such as appeared in many of the cases, related by me, unconnected with mesmerism: but which the shortness of time only has prevented me from witnessing. They, however, believed that they witnessed more than this. They declare they witnessed the production of sleep-waking by mesmerism practised in the next room to that in which the patient was; that they witnessed *clairvoyance*, — reading and perfect recognition of objects of sight, &c. amounting to the ability of playing games of cards, &c. in coma, with the eyes completely closed; accurate prophesying of the day of occurrence of distant epileptic attacks and of other events of the case; great diminution of epilepsy; rapid cure of hemiplegia; true declarations of the seat and nature of the diseases of strangers

by mesmerised persons in the state of sleep-waking who had never seen them before, but who were placed in relation with the patients by putting their hands in contact with them. The details are most interesting, and, in at least all particulars to which my own experience extends, I have no doubt most faithful. The report is signed by MM. Bourdois de le Motte, Fouquier, Gueneau de Mussy, Guersent, Husson, Itard, J. J. Leroux, Marc, and Thillaye.

After translating this report, Mr. Colquhoun refers to some cases of mesmeric sleep-waking in which it is said that the surface of the body acquired a new power of sensation; some related by M. Tardy de Montravel[a] of the recognition of objects of sight by the epigastrium even at some distance; one by Dr. Gmelin[b]; one of a Scotchman named Macgill, a servant of a Russian ambassador, who resolved the man's cure should be attempted by mesmerism, and describes all the phenomena himself[c]; one of an epileptic boy at Jena, magnetised by Professor Kieser[d], with the effect of producing various nervous symptoms, coma, convulsions, chorea, tetanus, and at length perfect sleep-waking, in which, though the eye appeared quite blind, objects of sight were recognised by his toes, fingers, elbows, shoulders, abdominal and facial surface, chin, and point of the nose. Similar cases without end are recorded in works on mesmerism.[e]

[a] *Traitement Magnétique de la Dem. N.* vol. i.

[b] *Material für die Anthrop.* vol. ii.

[c] *Biblioth. du Magn. Animal,* vol. iii. p. 126.

[d] *Archiv fur den thierischen Magnetismus,* vol. iii. No. 2.

[e] The work of Mr. Colquhoun is meritorious in a literary point of view — for the industry and ardour employed in it, and for the total disregard of the laughter of the ignorant and prejudiced world at large, and of the contempt of men who, eminent in one department of science, consider themselves authorities in matters which they have never studied. It is valuable also for the translation of the French Report, which had never been published and was merely lithographed and distributed among the members of the Academy. But I fear it is calculated to do far more harm than good from its displaying enthusiasm, and an inordinate love of the marvellous, whether true or false, instead of knowledge and judgment. It contains an Appendix, entitled, *A New Theory of Physics,* which any one acquainted with physics will perceive to be replete with mistatements and illogical inferences. Phrenology he abhors, and displays the grossest ignorance of it, making statements totally at variance

My readers will remember the extraordinary, but unquestionable, case of Colonel Townsend (*suprà*, p. 485. sqq.), who some

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with facts.* (Vol. ii. p. 120. sq., 150.) So credulous is he, that he considers the learned and amiable Swedenborg to have been naturally in a state of magnetic illumination, whom any one conversant with Swedenborg's theological writings, and with the history of insanity, must know to have been a monomaniac for thirty years. The mad Joan of Arc he supposes to have been in an habitual crisis. He believes every childish tale without a shadow of authenticity (vol. i. p. xxx. 87. sq.), every absurdity advanced by mesmerisers,—that mesmerised people speak, not merely understand, when spoken to by others influencing them mesmerically, languages unknown to them; he applies ridiculously extravagant terms of praise to ordinary persons, and considers a certain production as highly satisfactory,—just what he himself would have executed,—but which any man of sense and good feeling will agree with me to have been too contemptible, intel-

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* As a specimen of his knowledge and mind, I refer to a note in vol. ii. p. 153. He has "good reason to believe" that the brain is the seat of the operations of intellect, but equally good to hold "that the ganglionic system, the nerves of the chest and abdomen, is the primary seat of the affections!" Love, hate, jealousy, &c. alter the functions and even the structure of these organs, and any effect of these passions "upon the brain appears to be merely secondary and sympathetic!" Shame makes the cheek blush; shame therefore has its primary seat in the cheeks. We may go farther: disorder of the stomach causes headach; dyspepsia therefore has its primary seat in the head, and any effect produced upon the stomach appears merely secondary and sympathetic.

I must take this opportunity of supplying an omission on the subject of phrenology. All persons give Dr. Spurzheim the credit of inventing the term phrenology for his master's science: and he takes this credit, for, in his *Phrenology*, vol. i. p. 12., he says, "In extending my views, I have found it necessary to change the name again. I have chosen that of phrenology, which is derived from two Greek words, φρην, mind, and λογος, a discourse, and I understand by it the doctrine of the special phenomena of the mind, and of the relations between the mental dispositions and the body, particularly the brain." Now, Dr. Forster, in his *Recueil des Ouvrages et des Pensées d'un Physicien et Metaphysicien*, par Thomas Forster, Francfort sur le Mein, 1836, p. 12., proves that he himself gave the name: "I introduced my friend (Dr. Spurzheim) to the converzationi of Sir Joseph Banks, which were held every Sunday evening in Soho Square, and to many other men of science; but the greatest benefit I rendered him was to give him a suitable name for his system. In 1816 I published my *Sketch of the Phrenology of Gall and Spurzheim*, London, 1816;—a name which the science has never lost."

time before his death possessed the power of gradually reducing the action of his heart till it became imperceptible and for half

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lectually and morally, for me to condescend to notice. Materialism is as great a horror to him as phrenology; and he fancies that mesmerism proves the existence of a soul independent of body, and is doing wonders by weaning people "from the deadly error of materialism and infidelity, and giving birth to a sound and religious faith." (Vol. ii. p. 176.) He is thus ignorant that materialists may not only believe in God, but in the divine authority of Scripture; and more honour Scripture by looking implicitly in full faith to it alone, as God's authority, for their belief in a future state, than those who endeavour to make its declarations more probable by fancying a soul immortal in its own nature and independent of matter, when the Scripture tells us we shall rise as matter, — with bodies, and go to heaven with bodies, where Christ, God himself, sits bodily, — as matter, flesh, blood, and bones, in the words of the Church of England. (See my arguments at pages 39. sqq., 360. sqq.)

He supposes that, when Negretti had dressed a salad and then ate first cabbage and then tart instead, without perceiving the trick, and did not know that he was drinking water when he had called for wine, his "soul only was busy, without any co-operation of the body." (Vol. i. p. 344. sq.) Negretti's immaterial soul was resident in his brain, however, at the time, because Negretti was eating and drinking and doing a great many things with his body set in action by his brain, which was evidently hard at work. He conceives that in sleep there is always dreaming,— that the soul can never sleep, but is always at work; and that, when we are conscious of dreaming, it is only that the soul is struggling to manifest its independent activity without the co-operation of the bodily organs. (Vol. ii. p. 121.) It is a pity that the soul does not succeed; for, when acting only half followed by the brain, it works much worse than when completely so, our dreams being generally absurdities. (See *suprà*, p. 626.) I wonder why we should not recollect what our soul does in sound dreamless sleep without the co-operation of the brain: surely it must have memory. I wonder why, if it works so well without the brain, nature entangles it in a brain at all.

In mesmeric sleep-waking he contends that all has proceeded without the brain. The sleep-waker "remembers nothing, because the soul acts perfectly without the body, and every thing has taken place out of the brain, since we have seen that the fluid goes in search of objects." (Vol. ii. p. 159.; vol. i. p. 302.) In the subsequent fit, however, all is remembered, and yet the fluid must be again gone out in search. It must, therefore, be at home and abroad at the same time. So powerful does he believe the soul unencumbered by body to be in sleep-waking, that he actually declares not only that he is not aware of a sleep-waker perishing in the dangers which he frequently encounters, but that "so long as he is left undisturbed in his proceedings he acts fearlessly and is safe,"—"that he is protected from injury by other means and guarantees of security than those by which his conduct is regulated in his ordinary waking

an hour he appeared really dead. Bernier informs us that Indian Bramins and Fakirs can throw themselves into somnam-

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state." I have frequently read in the newspaper of persons opening the window and being dashed to pieces in their sleep. But, waving this, we saw that Negretti struck himself against a door which was shut without his knowledge, and once hurt himself severely against a wall (p. 640.): that Galen was awakened by striking against a stone: and that Mr. Dubree in his sleep threw himself out of the window and broke his leg. Besides the soul must be very stupid in sleep-waking, while it is doing the more wonderful things, — seeing with the surface, it is not aware of half that is existing and doing around. (See for instance *suprà*, p. 635. 637. 640. sq.) Supposing that persons perceive, independently of touch, by their surface, this shows no immaterial substance independent of matter to be at work, for the material surface is concerned in the operation. If the mesmerised person has intelligence of the past, present, and future, in regard to others as soon as they are put into relation with him by contact or intermediate communication, the unconnected, detached, immaterial substance must be a strange substance, which, to do these wonders, requires material bodies and their conjunction. At any rate, there is no *detached* immaterial essence at work. But I am weary of such nonsense. Any person of common discernment, unbewildered by fancies and unfettered by the intolerance of conceit and prejudice, must perceive that all the phenomena of sleep-waking are the effects of disorder of the matter called nervous system; coexist or are variously interchanged with all kinds of disorders of this part of the animal body; and are often attended by common bodily symptoms — heat, pain, throbbing, flushing of the head, &c.; and arise from the same causes as other nervous diseases, — mechanical injury, derangement of some distant part, &c.; and are sometimes hereditary. Brutes are influenced by mesmerism like human beings; and even vegetables, and inanimate matter. If mesmerism can act at a distance, so, let us remember, can gravitation, affinity, and other properties of inanimate matter. The soul, in the mesmerised, has disconnected itself from the brain! the fluid (is the fluid the soul? is not fluid still matter?) has gone out in search of objects! Where is it? and when out, how happens it to learn so little? to see only what is passing with respect to certain persons? to see only one person perhaps dying? or does the soul of the dying person go to its friends for a moment and show itself in those remarkable cases of the fancied sight of dying distant friends? The soul flies out under the manipulations of the magnetiser, and then flies away home again, knowing its way to the original skull, like a little material dickybird. Mr. Colquhoun's views are fit only for old divines and nursery maids. An enlightened Christian will scorn the support of any thing for his revelation but its plain evidences; these he will consider all-sufficient; and above all will he scorn the assistance of mesmerism, when he reflects, — a fact which Mr. Colquhoun does not mention, that some of the greatest mesmerists, — those who believe things which I will not believe till I see them, but which he believes, — contend that all the prophecies of the Old and New

bulism, and even teach the art.[f] Cardanus professed to be able to place himself in ecstatic insensibility.[g] St. Austin tells of a priest, named Restitutus, who could become insensible and lie like a dead man whenever he pleased, insensible to blows, punctures, burning, though if persons spoke loudly he heard something like distant sounds.[h] We have a modern account of a similar nature:—A man in India, "is said by long practice, to have acquired the art of holding his breath by shutting his mouth and stopping the interior opening of the nostrils with his tongue; he also abstains from solid food for some days previous to his interment; so that he may not be inconvenienced by the contents of his stomach, while put up in his narrow grave; and, moreover, he is sewn up in a bag of cloth, and the cell is lined with masonry and floored with cloth, that the white ants and other insects may not easily be able to molest him. The place in which he was buried at Jaisulmer is a small building about twelve feet by eight, built of stone; and in the floor was a hole about three feet long, two and a half feet wide, and the same depth, or perhaps a yard deep, in which he was placed in a sitting posture, sewed up in his shroud, with his feet turned inwards towards the stomach, and his hands also pointed inwards towards the chest. Two heavy slabs of stone, five or six feet long, and broad enough to cover the mouth of the grave, so that he could

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Testament, and all the miracles relating to the animal frame, were only so much mesmerism, and that Christ was but an extraordinary mesmeriser. A celebrated living mesmerist asserted this in a public lecture at Montpellier, and the people soon afterwards took up stones to stone him and endeavoured to drive him out of their city. Mr. Colquhoun himself quotes at great length a fierce tirade against the Bible, calculated, I should think, to produce great irreverence of the book.

Mr. Colquhoun would have rendered real service to mesmerism, if, instead of compiling so much rubbish, and displaying such ignorance and credulity, with a dogmatism and coarseness (vol. i. p. 136.; vol. ii. p. 162. sqq.) which have prevented me from being at all delicate with respect to him, he had collected unquestionable facts only and gone to work experimentally, like a philosopher, and communicated his results to the public.

[f] *Cérémonies et Coutumes réligieuses,* t. vi. p. 188.

[g] "Quoties volo, extra sensum quasi in ecstasin transeo." *De rerum varietate,* l. viii. c. 43.

[h] *De civitate Dei:* all quoted in *Isis revelata,* vol. i. p. 146. sq.

not escape, were then placed over him, and I believe a little earth was plastered over the whole, so as to make the surface of the grave smooth and compact. The door of the house was also built up, and people placed outside, so that no tricks might be played nor deception practised. At the expiration of a full month, that is to say *this morning*, the walling of the door was broken, and the buried man dug out of the grave; Trevelyan's moonshee only running there in time to see the ripping open of the bag in which the man had been enclosed. He was taken out in a perfectly senseless state, his eyes closed, his hands cramped and powerless, his stomach shrunk very much, and his teeth jammed so fast together, that they were forced to open his mouth with an iron instrument to pour a little water down his throat. He gradually recovered his senses and the use of his limbs; and when we went to see him was sitting up, supported by two men, and conversed with us in a low, gentle tone of voice, saying that 'we might bury him again for a twelvemonth if we pleased.'" The narrator is Lieut. A. H. Boileau, an officer of engineers, employed on the extensive trigonometrical survey of India. The Indian is now alive, and he voluntarily agreed with Esur-Lal, one of the ministers of the Muharàwul of Jaisulmer, to be buried for a month. There may be after all some trick; but Cornet Macnaghten once suspended him for thirteen days in a close wooden box. Previously to his interments he takes milk only, and of that no more than is sufficient to support life: and during it his hair ceases to grow.[1]

Besides sleep, various diurnal revolutions take place in the animal system. We have seen that the pulse is generally thought to be quicker in the evening than in the morning: that the formation of carbonic acid in the lungs was found by Dr. Prout in experiments upon himself to increase from daybreak to noon, to decrease from noon to sunset: that muscular power in Dr. Edward's experiments increased during the first half of the day and decreased in the latter. I have noticed for twenty years a

[1] *India Journal of Medical and Physical Science.*

diurnal revolution in my intellect and feelings: in the morning my intellect is stronger, as is that of all persons necessarily after repose; but in the evening all my social feelings are strikingly more acute. I often am deeply distressed in the evening, when reflecting on the loss or absence of those dear to me, and at the misfortunes of others not connected with me, till the very moment I go to bed and fall asleep; and in the morning can reflect upon the very same things with coolness, and perhaps am indisposed to reflect upon them at all.

Again, brutes have their seasons, — periods in which certain propensities become ungovernable, — for travelling, for singing, building, for the joys of love.

Morbid phenomena frequently have periodical recurrences — fever, pain, epilepsy, &c.,— and the intermission may be hours, days, weeks, months, years.

All brutes, probably, except those whose life is of very short duration, sleep. They sleep, however, at different periods of the twenty-four hours; so that according to their waking period they have been divided into diurnal, crepuscular, and nocturnal. Though darkness is not the cause of sleep, its effect upon diurnal birds is strikingly shown, if darkness supervenes in the day: I have been amused to see my birds go to sleep in the morning during a solar eclipse, and awake again when it was over. Those which prey by night, like the cat, see better in darkness from the structure of their eyes, and pass the greater part of their time in sleep; while those which do not, are awake the greater portion of the twenty-four hours. The former are said to reverse their natural habits if in captivity, and to sleep at night. Carnivorous brutes sleep more than herbivorous. Most brutes, we are informed, sleep longer in winter than in summer. Brutes generally have a certain character of sleep; all hares, cats, birds (a goose is a far better night watch than a dog), &c. being light sleepers: bears, badgers, turtles, &c. heavy sleepers. Some, as the hare, always sleep with their eyes open (Dr. Macnish, p. 25. sqq.): some sleep well standing, and horses have been known to stand for thirty days. Those which eat at long intervals, as some reptiles, have been observed to sleep for days after their enormous meal.

Plants have been said to sleep, from periodic changes in the position of an entire leaf or of the several leaflets of which a compound leaf is formed. The leaf stalks bend upwards or downwards, so that the flattened surface of the leaf is elevated or depressed: the upper surface of some leaflets and the under of others is brought together. These changes are influenced by light and heat, but not primarily induced. For, in a darkened room, the leaflets of sensitive

plants periodically fold and open: if excluded from light by day, and exposed to strong lamp-light by night, the periods of sleep become irregular at first, but generally, at length, the leaves close by day and open at night. The alternate opening and closing of flowers is analogous, but take place at different periods in different species, and not at the same period with the same changes in the leaves. An acacia has closed its leaves and expanded its flowers at sunset, and expanded its leaves and closed its flowers at sunrise. (Prof. Henslow's *Principles of Descriptive and Physiological Botany*, in Lardner's *Cyclopædia*, p. 171. sq.)

The functions of plants are very periodical: leafing and flowering occur at certain periods. The regular return of the seasons influences their periodicity, but there is a natural independent tendency to it which, though assisted by the vicissitudes of the season, causes the changes of individuals to be considerably accelerated or retarded. (Prof. Henslow, l. c. p. 149. sq.)

The phenomena of hybernating animals, which grow dull on the approach of winter, and at length fall asleep, continuing so till the return of mild weather, and generally endeavouring to be as little exposed to noise, motion, and all causes of excitement, and to lose as little heat during the approaching cold as possible, by coiling themselves up and getting into holes and warm situations, covering themselves with leaves, &c. (and all the classes of animals, except birds, contain species that have the faculty of living in this state), are precisely analogous, though very different in degree, to those of common sleep. The sensibility and all the functions are lessened, the temperature becomes nearly as low that of the surrounding medium, the circulation slow, respiration almost or quite imperceptible, and digestion suspended. Although all activity is thus reduced in the hybernating state, vitality becomes more tenacious,—is less easily extinguished. Mangili cut off the head and neck of a marmot in the state of hybernation in March, and put it in spirits, yet movements were evident in it at the end of half an hour, and galvanism produced strong contractions in pieces of voluntary muscles three hours after they had been cut off; and even *four* elapsed before their excitability was much diminished: the heart beat for three hours after decapitation. He made the same examination in June with a marmot which had been out of hybernation two months; the muscles showed little excitability under galvanism at the end of *two* hours, and the heart ceased to beat in fifty minutes after decapitation. (*Annales de Museum*, t. x. p. 453. sqq.) This is what we should have expected. The augmented tenacity of life, which allows food, air, and heat to be dispensed with in whole or in part, is likely to pervade the muscles and indeed every part of the frame; just as the necessity for air, food, and heat is in all other cases proportionate to the want of tenacity of excitability in muscles and of all vital properties. The sensibility is not so diminished but that "the slightest touch applied to one of the spines of the hedgehog immediately roused it to draw a deep and sonorous inspiration; the merest shake" induces a few respirations in the bat. (Dr. Marshall Hall, *Phil. Trans.* 1832.*)

* This gentleman endeavours to show that an inverse ratio prevails between respiration and irritability, in which word he includes both tenacity and sus-

This torpidity is produced by a *deficiency* of external excitants, usually by cold and want of food, and, in the language of Brown, is a state of direct debility, while our ordinary sleep is one of *indirect* debility, — exhaustion. No structural peculiarity is discoverable, which enables certain animals to exist in the torpid state.

Such animals at all times produce less heat, and vary more with the surrounding medium, than others, so that Dr. Edwards in an hour cooled a dormouse 36° by surrounding it with a freezing mixture, which caused a reduction of not more than 5° or 6° in adult birds and guinea-pigs exposed to it for even a longer time. (l. c. p. 154. sq.) Some which do not hybernate resemble them in this inferior power; mice, for example, which, therefore, at all ages and seasons make themselves nests. (p. 259.) On the other hand, hybernating animals are not all equally deficient in the power of resisting the influence of surrounding low temperatures; dormice are the most so, marmots the least; so that animals which preserve their own temperature in low media, and those which readily follow the surrounding temperature, are not widely separated, but insensibly run into each other, (l. c. p. 257. sq.) to say nothing of the inferior power of the newly-born among many of the former, and among all if born before full time, and of the various degrees of this power in different adults, and in all at different seasons of the year. (See section on animal heat.) Cold produces sleep in all, and if the sleep is indulged, death is the result in those which cannot hybernate. Those which can, become more and more torpid, by the mere continuance of the same degree of cold. A very intense degree of cold has been found actually to arouse animals in a state of torpidity, but the excitement of the functions could not continue long, and death ensued. (p. 398.) It appeared necessary that respiration should be suspended in an experiment of M. De Saissy, who, by mere cold, could not produce torpor in a marmot till he closed the lid of the vessel in which it was placed. (p. 154.) Hence, exposure to carbonic acid, hydrogen, &c., in this state, was found by Spallanzini to have no ill effect upon a torpid marmot. (*Rapports de l'Air*, t. ii. p. 207.) Yet respiration has often seemed not to cease entirely. (See Dr. Reeve, *Essay on the Torpidity of Animals.*) The blood has been found in a certain degree coagulated in torpid bats. (Hunter, *On the Blood*, p. 25.) Cold, at any time of the year, will produce the torpid state, but want of food must greatly assist in lessening the power of maintaining temperature. On the other hand, a continual good supply of food and warm temperature increases their power of evolving heat, and enables them to resist the power of cold, so that, by domestication, some cease to hybernate in the winter. (Dr. Edwards, l. c. p. 472.) Dr. Edwards found that the temperature of hybernating animals sinks considerably during sleep, even in summer. (p. 473.)

Fish, and other cold-blooded animals, will survive an intense torpidity. "The fish froze," says Captain Franklin, "as fast as they were taken out of the nets,

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ceptibility. I conceive that the whole is but one fact: — that animals which retain their powers well under privations, must be those which require less frequent and less abundant supplies of food, air, &c.; and that respiration is less in them from the less necessity of stimuli to support the system.

and in a short time became a solid mass of ice, and by a blow or two of the hatchet were easily split open, when the intestines might be removed in one lump. If in this completely frozen state, they were thawed before the fire, they recovered their animation." "We have seen a carp recover so far as to leap about with much vigour, after it had been frozen for six and thirty hours." (*Journey to the Polar Sea*, p. 248.) Izaak Walton (*The Complete Angler*, p. 257.) quotes Gesner for the fact of some large breams being put into a pond which was frozen the next winter into one mass of ice so that not one could be found, and all swimming about again when the pond thawed in the spring, — a thing "almost as incredible," says the sentimental sinner, as Lord Byron calls him, "as the resurrection to an atheist."

Insects easily bear torpidity from cold. In Newfoundland, for example, Captain Buchan saw a frozen lake, which in the evening was all still and frozen over, but, as soon as the sun had dissolved the surface in the morning, was in a state of animation, owing, as appeared by close inspection, to myriads of flies let loose, while many still remained "infixed and frozen round." Ellis also mentions that a large black mass, like coal or peat, upon the hearth, dissolved, when thrown upon the fire, into a cloud of musquitoes. (*Quarterly Review*, 1821, April, p. 200.) Those insects which hybernate are not thought by Kirby and Spence (*Entom.* vol. ii. p. 460. sqq.) to prepare for and enter into that state solely from cold, &c., as they do so when the season comes round, although the weather be as warm as previously, and do not before this period, though the temperature chance to be as low as it usually is in the season of hybernation.

Some animals become torpid on being deprived of moisture, — the most simple infusoria, rotifera, vibriones for instance. A common garden snail falls torpid if put in a dry place, and may be revived at any time by the application of a little water. Moisture has revived some animalcules after a torpidity of twenty-seven years. (Spallanzani, *Opuscoli di Fisica animale e vegetabile.*) The same is true of some of the most simple vegetables, as mosses. The microscopic wheel animal, after remaining three or four years as a shrivelled point, capable of being broken to pieces like a crystal of salt, is still recoverable by a drop of water: and the eel of blighted corn (*vibrio*), after twenty or thirty years. Yet electricity destroys their capability of resuscitation. Most vegetables become torpid in winter. Many lichens and mosses, dried in herbaria, have been restored to life by moisture after a century or two. Seeds and bulbs which have remained for centuries in the bowels of the earth have sprung into life on being thrown into a more congenial soil: and bulbs, taken from the hand of a mummy found in one of the pyramids, after having been immured between two and three thousand years, produced unknown plants when sown in one of our botanic gardens. (Dr. Fletcher, l. c. P. ii. b. p. 144.) Still more lately, a writer of rank, Baron Herberstein, who was twice ambassador in Russia from the Emperor Ferdinand, informs us, in his *Commentaries on Russian History*, that, in the northern parts of Muscovy, near the Oby, on the borders of Tartary, a people called Leucomori hybernate "like tortoises, under ground," "quite frozen," from the 27th of November to the 23d of April, when "they come to life again." No specimens have yet been imported into this country.

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